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# UNDERSTANDING BIOFILM: TREATMENTS & CONTROVERSIES



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microjet wound therapy MWT

Biofilms are a community of micro-organisms that are encased in a protective extracellular polymeric substance<sup>1,2</sup>, that act to protect the microbes from host immunity whilst also rendering them more tolerant to the action of antimicrobials<sup>3</sup>. Although biofilms are microscopic and cannot be seen with the naked eye<sup>4</sup>, they are ubiquitous in chronic wounds<sup>5</sup> and lead to chronic inflammation and therefore delayed wound healing<sup>6</sup>. Biofilms are often identified as a shiny, translucent, slimy layer in the wound bed that returns quickly after sharp debridement<sup>7</sup>.

Some of the greatest debates in the treatment of these chronic wounds relates to the role of biofilm. For example, what is the bacterial composition of biofilm? Is bacterial composition of biofilm consistent between patients and over time? Is biofilm itself detrimental to wound healing? Or more controversially, could some biofilm even aid wound healing?

## **Biofilm Composition**

Although there is much debate around the role of microbes and biofilm in chronic wounds, one fact that is widely accepted is that microbial diversity of wounds is more complex than once thought<sup>8,9</sup>, with the majority of chronic wounds, if not all, being poly-microbial in nature<sup>10</sup>. Indeed, an analysis of samples taken from Venous Leg Ulcers revealed that *Staphylococcus aureus* was found in 88% of wounds along with *Enterococcus faecalis* in 74%, *Enterobacter cloacae* in 29%, *Peptococcus magnus* in 29%, and fungi in 11%<sup>11</sup>. Data also points to the bacterial content of the biofilm in chronic wounds continually changing<sup>12</sup> which results from the dynamics in the wound evolving over time, allowing for the proliferation of other Gram-positive and Gram-negative bacteria, in addition to anaerobic bacteria and yeast<sup>4</sup>. As such, the longer a wound remains unhealed, the more likely it will be to acquire multiple aerobic (average of 4.3 species) and anaerobic bacteria (average of 2.0 species)<sup>13</sup>. Further, evidence has shown that in the chronic wound, anaerobic bacteria do represent a large proportion of the wound microbiota<sup>14,15</sup>. Although the role of aerobic bacteria in biofilm is well documented, the role of anaerobic bacteria remains poorly understood. This is despite there being evidence that they play a role in delaying healing and prolonging infection<sup>4</sup>, and as such is an area of chronic wound care warranting further investigation.

## **Biofilm & Wound Healing**

But what role do the bacteria in biofilm play in the stalled wound healing process? Animal models have shown that the presence of the gram-positive bacteria, *Staphylococcus aureus* and the gram-negative bacteria, *Pseudomonas aeruginosa* in biofilms significantly delay wound healing<sup>16</sup> and that this is due to a delay in epithelialization and the formation of granulation tissue<sup>17,18</sup>. It has also been suggested that the degree to which biofilm delays wound healing can be quantitated, with an amount in excess of 10<sup>5</sup> bacteria per gram of tissue being sufficient to impede wound healing<sup>19</sup>, while animal studies have shown that biofilm physically impairs the immune responses associated with healing<sup>20,21</sup>. However, there is evidence that colonisation of the wound with skin microflora can actually aid wound healing<sup>22,23</sup>, and it is hypothesised that this healing is due to local inflammation increasing wound bed perfusion<sup>24</sup>. These seemingly contradictory data leads to the interesting possibility that infection of wounds with certain types of microbes result in chronic wounds while others can expedite wound healing.

## Biofilm Treatment Options

The most common antimicrobial treatment options for biofilm include the use of topical antiseptics and antibiotics. The topical antiseptics include alcohol, iodine, chlorhexidine, chloroxylenol, silver compounds, triclosan, and hydrogen peroxide<sup>25</sup>. The use of antiseptics has been controversial due to their potentially cytotoxic nature, or that some contain detergents that are too harsh for use on a wound. As such the US Department of Health and Human Services strongly discourages the use of antiseptics, recommending the use of normal saline only<sup>23</sup>. Meanwhile, research has shown that bacteria in biofilm are 500 times less susceptible to antibiotics than in their planktonic forms<sup>26</sup>. It is therefore not surprising that a Cochrane review investigating the efficacy of antibiotics for chronic venous ulcer concluded that the current evidence does not support the use of systemic antibiotics to treat venous leg ulceration<sup>27</sup>. There is however data to suggest that the use of antimicrobials is most efficacious when debridement was first used to reduce the bioburden before the application of the antimicrobial therapy<sup>28</sup>, with regular debridement having been shown to open a short therapeutic window where bacteria are more susceptible to antimicrobial agents<sup>29</sup>.

## Biofilm & the Efficacy of Debridement

Debridement is the simplest and most effective method to remove barriers to healing such as biofilm<sup>30</sup>. But even so, biofilm returns rapidly, with some suggesting this may be within hours<sup>31</sup>, and others 2-4 days<sup>32</sup> making regular debridement the key to wound healing<sup>29,33</sup>. The best practice management of a contaminated wound is to remove contaminants while inflicting minimal injury to tissues<sup>34</sup>. However, to date, sharp debridement remains the most effective procedure for the removal of biofilm, even though this creates tissue injury and discomfort for the patient<sup>33</sup>. Since mechanical force and shear is required to break up and disrupt the biofilm, debridement that does not achieve bleeding, such as autolytic debridement, is not effective<sup>35</sup>. This apparent contradiction between requiring sufficient mechanical force to disrupt the biofilm but not applying too much force as to cause tissue injury, creates a challenge for clinicians performing debridements using sharp debridement methods. It has been suggested that there is clearly a need for new medical devices that are able to interfere with the complex biofilm communities that exist in non-healing wounds<sup>30</sup>. But is this possible in the context of debridement? A recent study observed a case where a chronic infection of a large wound was eliminated by the use of a new Micro Water Jet Technology<sup>32</sup>. This technology (debritom+) allows for the application of impact pressure on the wound to be modulated through the choice and type of hand piece, and also by the distance and angle the hand piece is held from the wound<sup>36</sup>. By offering the clinician fine control over the impact pressure on the wound, the debritom+ empowers the debriding physician to achieve the required mechanical force to eliminate biofilm while avoiding the tissue injury commonly associated with sharp debridement – all without physical contact with the wound bed. Although this Micro Water Jet Technology remains relatively new to market, there is evidence that the use of this technology can improve the rate of wound healing by 30%<sup>32</sup>. Although it is unclear as to whether the observed faster wound healing is due to a reduction in tissue damage or an improved efficacy of debridement, these findings offer a tantalising insight into the future of best practice debridement.



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