Clinical management of non-healing wounds


Edwin Tapiwa Chamanga
Senior lecturer in primary care and tissue viability, Faculty of Health, Social Care and Education, Kingston University and St George’s, University of London, London, England

Correspondence e.chamanga@sgul.kingston.ac.uk
@edwin_chamanga

Conflict of interest None declared

Abstract
Chronic wounds are defined as those that have failed to heal after three months. There are various intrinsic and extrinsic factors that may result in the development of chronic wounds, including comorbidities such as diabetes mellitus and venous insufficiency, and lifestyle factors such as obesity, alcohol consumption and smoking. Chronic wounds represent a significant burden on healthcare resources and can have a negative effect on patients’ quality of life. This article discusses the assessment and treatment of non-healing chronic wounds. It examines the normal wound-healing process and the management of chronic wounds, including advanced interventions such as electrical stimulation therapy, negative pressure wound therapy and various dressings. This article does not focus on specific wound types; instead, it provides an overview of the factors that can lead to the development of chronic wounds and how these wounds can be managed in clinical practice.

Keywords
chronic wounds, extracellular matrix, infection, inflammation, non-healing wounds, wound assessment, wound bed preparation, wound healing

Aims and intended learning outcomes
The aim of this article is to explore the development of chronic wounds and their management in clinical practice. It also examines the normal wound-healing trajectory to demonstrate the points at which a healing wound can become a chronic non-healing wound. After reading this article and completing the time out activities you should be able to:
» Explain the normal wound-healing process.
» Identify the intrinsic and extrinsic factors that can lead to the development of chronic wounds.
» Understand the principles of wound management.
» Outline the interventions that can be used to manage chronic wounds.

Relevance to The Code
Nurses are encouraged to apply the four themes of The Code: Professional Standards of Practice and Behaviour for Nurses and Midwives to their professional practice (Nursing and Midwifery Council (NMC) 2015). The themes are: Prioritise people, Practise effectively, Preserve safety, and Promote professionalism and trust. This article relates to The Code in the following ways:
» It assists nurses to assess and treat chronic non-healing wounds. The Code states that nurses must prioritise people by assessing and responding to their needs.
» The Code states that nurses must ensure that patient safety is protected. This article equips nurses with the knowledge to undertake an accurate assessment of a patient’s wound and identify potentially harmful developments, such as wound infection.
» The Code emphasises that nurses must focus on preventing ill health. Comprehensive knowledge of the normal stages of wound healing enables nurses
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to identify when a wound is at risk of becoming chronic and act to prevent this.

Introduction

Chronic wounds are defined as those that fail to heal within a predicted timeframe (Frykberg and Banks 2015). Most wound care protocols recommend the use of standard wound care, for example debridement and application of a suitable wound dressing, for an initial period of four weeks. At this time, the wound should be reassessed for any reductions in surface area, as well as signs of healing, such as healthy granulation tissue (Frykberg and Banks 2015). A wound that has not progressed along the healing trajectory after three months is usually considered to be chronic (Iqbal et al 2017).

Chronic wounds are also known as hard-to-heal wounds, non-healing wounds, recalcitrant wounds, and challenging or complex wounds (Legerstee 2009, Vowden 2011). Wounds that commonly become chronic include pressure ulcers, diabetic foot ulcers, leg ulcers and non-healing surgical wounds (Frykberg and Banks 2015). The prevalence of chronic wounds is rising, partly because of ageing populations and increased longevity (Moore et al 2014, Probst et al 2014). However, it is important to note that chronic wounds do not only affect older people, but can also affect younger people, depending on the individual’s physical health status. For example, patients whose mobility is reduced following surgery are at increased risk of developing chronic pressure ulcers (Medical Advisory Secretariat 2009).

During the normal wound-healing process, a balance of healthy proteins and enzymes, including neutrophils, macrophages and proteases, promote healing in the wound bed. Any disruption in this balance can result in the development of a chronic wound (Harding et al 2002, Gethin 2007, McCarty and Percival 2013). Intrinsic factors, such as older age or the presence of co-morbidities such as diabetes mellitus, and extrinsic factors, such as lifestyle factors and medicines, can affect the chemical balance in the wound bed.

Chronic wounds develop when wounds, especially in older people and those with ischaemia, neuropathy and immobility, are not managed in a systematic way. Chronic wounds are associated with the following features (Price and Harding 2004, Fong and Wood 2006, McCarty and Percival 2013, Rüttermann et al 2013, Vowden and Vowden 2016, Järbrink et al 2017):

» Increased risk of infection and a build-up of bacterial bioburden, which occurs when bacterial cells secrete a variety of enzymes and toxins into the wound.

» High levels of exudate (wound fluid that leaks from blood vessels, especially during inflammation) and pain, which result in reduced quality of life.

» Use of long-term treatments, because chronic wounds are often ‘stuck’ in one phase of the normal wound-healing process.

» Financial burden to patients, for example through loss of earnings, and to healthcare providers.

» Emotional distress to patients, for example anxiety exacerbated by disturbed sleep.

» Reduced mobility, depending on the location of the wound; for example, leg ulcers and diabetic foot ulcers.

» Presence of multiple co-morbidities that affect the usual wound-healing process, for example diabetes and peripheral vascular disease.

Guest et al (2015) asserted that the cost of wound management to the NHS was £5.3 billion per year, while Posnett and Franks (2008) estimated that the management of chronic wounds specifically costs the NHS around £2.3-£3.1 billion each year. Chronic wounds are prevalent in adults aged over 65 years (Rüttermann et al 2013, Gould et al 2015), and the cost of managing this patient group is likely to rise as the population ages and there is an increase in the incidence of co-morbidities such as arterial insufficiency, venous insufficiency and diabetes, which can negatively affect the wound-healing process (Fonder et al 2008, Rüttermann et al 2013).

Early identification of chronic wounds and the use of effective treatments are essential in improving patient outcomes and reducing the financial burden on the NHS (Guest et al 2015, Vowden and...
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Vowden 2016). Diagnostic tools and clinical algorithms are available to support nurses in identifying chronic wounds, for example frameworks to assist nurses in determining the status of the wound bed (Dowsett et al 2015a), and the triangle of wound assessment that encourages nurses to consider the wound bed, wound edge and periwound skin when undertaking any assessment of chronic wounds (Dowsett et al 2015b). Similarly, innovative techniques for the assessment of chronic wounds include a point-of-care test that detects elevated protease activity, which can cause chronic inflammation and impede wound healing (National Institute for Health and Care Excellence (NICE) 2016a). Advanced topical dressings are also available, which are aimed at reducing the amount of proteinase on the wound bed, thus reducing the risk of wound chronicity (Gardner 2013).

**TIME OUT I**

List the differences between a chronic wound and a wound that is healing normally. Using your notes, prepare a brief teaching session for your colleagues on how to distinguish between a chronic non-healing wound and a healing wound.

**Normal wound healing**

Wound healing is a complex and dynamic process by which the skin repairs itself (Meyers and Hudson 2013). It is characterised by a series of events that occur from the time of the injury to the point of wound healing and which are classed in four phases: haemostasis, inflammation, proliferation, and remodelling (Brown 2015). But in clinical practice these phases often overlap and some wounds become stuck in one phase, predominantly the inflammatory phase, which can lead to the development of a chronic wound (Fonder et al 2008, McCarty and Percival 2013). Table 1 outlines the phases of the normal wound-healing process (Stacey 2016).

**Haemostatic phase**

The first phase of the normal wound-healing process involves haemostasis. This begins as the blood vessels constrict (vasoconstriction), the platelets aggregate, and a clot is formed to prevent excess blood loss (Ng 2010).

**Inflammatory phase**

Inflammation is predominantly characterised by the presence of neutrophils and

<table>
<thead>
<tr>
<th>Phase</th>
<th>Timeframe</th>
<th>Cells involved</th>
<th>Function</th>
<th>Cellular and biophysical events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemostasis</td>
<td>Immediate</td>
<td>Platelets (also called thrombocytes and involved in blood clotting)</td>
<td>Clotting</td>
<td>Vascular constriction, Platelet aggregation, degranulation, and fibrin formation (thrombus)</td>
</tr>
<tr>
<td>Inflammation</td>
<td>Day 1-4</td>
<td>Monocytes, Lymphocytes, Neutrophils, Macrophages</td>
<td>Phagocytosis (ingestion of bacteria)</td>
<td>Neutrophil infiltration, Monocyte infiltration, and differentiation of macrophages, Lymphocyte infiltration</td>
</tr>
<tr>
<td>Proliferation</td>
<td>Day 4-21</td>
<td>Macrophages, Lymphocytes, Angiocytes, Neutrophils, Fibroblasts, Keratinocytes</td>
<td>» Re-establishment of skin function, Wound bed filling, Wound closure</td>
<td>» Re-epithelialisation, Angiogenesis (growth of new capillaries), Collagen synthesis</td>
</tr>
<tr>
<td>Remodelling</td>
<td>Day 21-year 2</td>
<td>Fibrocytes</td>
<td>» Develop tensile strength</td>
<td>» Collagen remodelling, Vascular maturation and regression</td>
</tr>
</tbody>
</table>

(Stacey 2016)
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macrophages in the wound bed and surrounding tissue, which combat any invading harmful microorganisms or foreign materials (Harding et al 2002). As the wound progresses through the phases of the healing process, neutrophils reduce in number and are replaced by macrophages (Meyers and Hudson 2013), which can ingest bacteria and alter the body’s immune function, for example to fight infection (Fujiwara and Kobayashi 2005).

**Proliferation phase**
In the proliferation phase, new granulation tissue is formed, which comprises microscopic blood vessels and elements that form the extracellular matrix (ECM), for example polysaccharides and elastin and collagen proteins. The ECM surrounds and supports cells in the body’s tissues and is the main component of the dermal skin. Fresh granulation tissue has a pink appearance and begins to fill the wound bed from the base upwards to the skin level, where epithelialisation will occur in the next phase of wound healing (Meyers and Hudson 2013). The growth of fresh granulation tissue is supported by angiogenesis (the formation of new capillaries) (Martin 2013).

**Remodelling phase**
Remodelling is the final phase of wound healing, in which the collagen content of the wound changes to become smoother and new epithelial cells adjacent to the wound migrate across the wound surface (Leoni et al 2015). Cells that were required to repair the wound are removed by apoptosis (programmed cell death). The remodelling phase involves closure of the wound edges (Meyers and Hudson 2013). It should be noted that, following total wound closure, the tissue on the healed wound site will retain 70-80% of the tensile strength of the original tissue (Meyers and Hudson 2013).

**TIME OUT 2**
Explain the four phases of the normal wound-healing process and the events that occur in each phase to a colleague. Think about the factors that led to any acute wounds you have encountered becoming chronic wounds.

**Role of matrix metalloproteinases**
Matrix metalloproteinases (MMPs) are enzymes that are essential for the wound-healing process. MMPs are produced by activated inflammatory cells (neutrophils and macrophages) and other cells involved in wound healing, for example epithelial cells and fibroblasts (cells that promote the development of connective tissue) (Gibson et al 2009) (Table 1). The role of MMPs is to (Armstrong and Jude 2002, Gibson et al 2009):
- Remove damaged ECM and bacteria.
- Prepare the capillary basement membrane for angiogenesis.
- Support the migration of epidermal cells.
- Enable ECM contraction and scar remodelling.

**Development of chronic wounds**
Chronic wounds commonly include vascular ulcers (including venous and arterial ulcers), pressure ulcers and diabetic ulcers. Features of chronic wounds include (Frykberg and Banks 2015):
- Prolonged inflammation.
- Infection.
- Formation of microbial biofilms.
- Inability of skin cells to repair the wound.
Disruption of the normal wound-healing process involves chemical imbalances in the wound bed that can lead to the development of a chronic wound (Gethin 2007, Guo and DiPietro 2010, Sussman 2014). For example, inflamed tissue at the wound site attracts neutrophils and macrophages, which, in turn, release reactive oxygen species, proteases and MMPs. While these factors are necessary to combat bacteria, they can also damage cells when not properly regulated (Eleri et al 2015). For example, an over-production of MMPs and a reduced secretion of tissue inhibitor of metalloproteinase over a prolonged period will begin to damage the proteins required for wound healing, leading to degradation of the ECM and development of a chronic wound (Gibson et al 2009, McCarthy and Percival 2013).

There are several intrinsic and extrinsic factors that can cause chemical imbalances in the wound bed. Intrinsic factors relate to the overall health or disease state of the
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Intrinsic factors
Age
Ageing results in changes to the structure and function of the skin, which may impair the rate and quality of the wound-healing process. For example, the skin of older adults is more fragile, thinner, less elastic and drier than in younger adults, with new cells being generated slowly (Vowden 2011, Meyers and Hudson 2013). In addition, the fatty content of the subcutaneous tissue, which protects against infections and trauma, decreases in older adults (Visser et al 2003, Raguso et al 2006, Tchkonia et al 2010). However, the major challenges associated with longevity are that patients present with multiple co-morbidities and polypharmacy, which can negatively affect the wound-healing process (Anderson and Hamm 2012, Gould et al 2015).

Stress
Sternberg (2006) reported that stress disrupts the neuroendocrine immune equilibrium, which causes a significant delay in wound healing by prolonging the inflammation phase. A prolonged inflammatory phase results in higher bacterial counts and increases the incidence of infection, which delays wound closure and the healing process (Engeland and Marucha 2009). Stress can also lead to anxiety, depression, suboptimal sleeping patterns, inadequate nutrition, reduced exercise and an increased susceptibility to alcohol consumption, cigarette smoking and drug use, all of which have a negative effect on wound healing (Godbout and Glaser 2006).

Diabetes mellitus
Patients with a diagnosis of diabetes are at risk of presenting with multiple co-morbidities, including suboptimal wound healing and chronic ulceration as a result of microvascular and macrovascular complications (Vowden 2011, Okonkwo and DiPietro 2017). While the diagnosis of diabetes does not automatically mean that a patient’s wound will become chronic, patients with suboptimally controlled blood glucose levels are at high risk of developing chronic wounds because of hypoxia, dysfunction in the role of fibroblasts and epidermal cells, and impaired angiogenesis and neovascularisation (the natural formation of new blood vessels) (Guo and DiPietro 2010).

Nutrition
Adequate nutritional intake is essential to enable wound healing because some patients lose large volumes of protein through wound exudate, and patients with wounds have a higher metabolic rate compared with those who do not have wounds (Guo and DiPietro 2010, Gould et al 2015). There are several aspects of nutrition that influence the wound-healing process. For example, protein deficiency can impair capillary formation, cell proliferation and wound remodelling, as well as reducing the efficiency of the immune system, thereby increasing the risk of infection (Gould et al 2015). Other essential nutrients for wound healing include vitamins A, B, and C, zinc, iron and copper (Molnar et al 2014). A referral to the dietetics service for assessment may be required if a person with a wound is suspected of having a suboptimal nutritional intake.

Obesity and being underweight also have a negative effect on the wound-healing process. Patients who are obese are at risk of compromised wound healing resulting from inadequate blood supply to the adipose tissue or protein malnutrition, while patients who are underweight may lack the oxygen and nutritional stores required for wound healing (Stacey 2016).

Extrinsic factors
Medicines
Some medicines, such as cytotoxic drugs, interfere with cell migration on the
wound bed, and may cause neutropenia (a lack of infection-fighting neutrophils in the bloodstream), leaving the wound bed susceptible to infection (Fonder et al 2008, Guo and DiPietro 2010). The use of antiplatelet agents, long-term corticosteroids and anti-inflammatory drugs suppresses the body’s usual inflammation process or disrupts the clotting mechanism, thereby disrupting the wound-healing process through vasoconstriction (Bale et al 2000, Fonder et al 2008). Because of prolonged vasoconstriction in the wound bed, the wound-healing process becomes disrupted, with an inadequate number of macrophages reaching the wound to facilitate the inflammation process (Gou and DiPietro 2010). This could potentially lead to the development of a chronic wound caused by a lack of growth factors or disruption from infection, because macrophages have a major role in combatting microorganisms (Fujiwara and Kobayashi 2005).

**Alcohol consumption**
Alcohol consumption impairs wound healing and increases the incidence of infection by suppressing the release of pro-inflammatory enzymes (Tonnessen et al 2012). It should be noted that the effects of alcohol on host defence depend on an acute or chronic pattern of alcohol consumption (Guo and DiPietro 2010). Excessive alcohol consumption has been found to affect the wound-healing process (Radek et al 2007).

**Smoking**
Smoking reduces the oxygen-carrying capacity of red blood cells, thereby inducing wound chronicity because the lack of oxygenated blood inhibits angiogenesis in the wound bed (Meyers and Hudson 2013). Stacey (2016) stated that nicotine causes vasoconstriction, which reduces blood flow to the skin. This results in tissue ischaemia, reduced proliferation of red blood cells, fibroblasts and macrophages, and impaired wound healing.

**Infection**
One of the functions of the skin is to provide protection to internal organs from external microorganisms; however, once the skin is injured the underlying tissue can become contaminated (Edwards and Harding 2004). It is essential that any contaminating microorganisms are removed or reduced, so that the inflammation phase of the wound-healing process is not prolonged (Gould et al 2015). The major function of neutrophils is to remove foreign material, bacteria and non-functional tissue, which may be present in the wound bed (Hart 2002). Phagocytosis occurs when neutrophils identify the chemical signals displayed by microorganisms and ingest them (Hart 2002, Sylvia 2003).

**TIME OUT 3**
List the various intrinsic and extrinsic factors that influence wound chronicity and affect the normal wound-healing process. How would you explain to a patient the effects that lifestyle factors, such as smoking and alcohol consumption, might have on wound healing?

**Chronic wound management**
Both acute and chronic wound management involve a holistic assessment and ongoing evaluations of the wound bed to support healing and improve the patient’s quality of life (Ousey and Atkin 2013). It is important that chronic wounds resume the normal healing trajectory as soon as possible. The first step in managing a chronic wound is to perform a holistic assessment, which includes reviewing the patient’s medical history, identifying any intrinsic and extrinsic factors that may affect healing, and assessing the wound bed. Timely wound assessments and reviews support effective clinical decision-making; however, Gethin (2007) noted that the clinical assessment of chronic wounds is often based on subjective interpretation, with little objective analysis.

Some of the objective tests that healthcare practitioners can use to assess a patient’s wound status include (World Union of Wound Healing Societies 2008):
- Physical observations:
  - Measuring the wound dimensions to monitor healing progress.
  - Monitoring oedema (build-up of fluid in the tissue causing swelling).
– Identifying the type of tissue present in the wound bed, for example black necrotic tissue, exposed bone and tendon.
– Identifying the characteristics of wound exudate, for example colour, odour, viscosity and volume.
– Identifying and assessing pain.

» Biological tests:
– White blood cell count to identify infection.
– Histology to assess vasculitis (inflammation of blood vessels).

» Biochemical tests:
– Blood glucose to exclude diabetes.
– C-reactive protein to identify inflammation.

» Other tests:
– Ankle brachial pressure index (ABPI), which assesses the extent of peripheral vascular disease.
– Body mass index, which assesses nutritional status.
– Duplex scanning, which assesses the severity of arterial occlusion in the lower limbs.

TIME OUT 4
Think about the main assessment techniques that can be used to identify a chronic wound. Have you assessed a patient with a wound in your practice recently? Which techniques did you use to assess the wound and would you use any alternative techniques in the future?

Wound bed preparation
Wound bed preparation is considered crucial to accelerate wound healing or to enhance the effectiveness of interventions designed to heal chronic wounds (Falanga 2000, Schultz et al 2003, European Wound Management Association 2004, Mattiasek et al 2014). Wound bed preparation involves identifying and eliminating factors that may hinder the wound-healing process, such as non-viable tissue in the wound bed or increased levels of exudate. This facilitates wound healing and provides an effective means of chronic wound management by promoting an understanding of the barriers to healing, providing a systematic approach, and enhancing the effects of advanced therapies (Schultz et al 2003).

Wound bed preparation can be summarised using the TIME framework (Figure 1) (Dowsett et al 2015a), which consists of four components:
» T – tissue. Is the tissue viable or non-viable? Is removal (debridement) of non-viable tissue, for example necrotic tissue and eschar, necessary to encourage wound healing?
» I – infection or inflammation. Are there any visible clinical signs of infection that need to be addressed to encourage the wound-healing process? These signs might include heat, redness, pain, swelling and odour.
» M – moisture balance. Is the wound environment moist enough to support the principle of moist wound healing?
» E – edges of the wound and epithelialisation. Are the wound edges non-advancing or undermining (deep tissue damage around the wound margin)? What are the characteristics of the wound edges? Are they thick and non-advancing (callus)? If so, they may require debridement.

The TIME framework (Dowsett et al 2015a) provides healthcare practitioners with a systematic approach to selecting appropriate wound interventions, and
should be implemented as part of a holistic assessment of any chronic wound. The TIME framework can also identify appropriate wound bed objectives, which can often change during the wound-healing process, for example:

- **Debride** – to remove the non-viable tissue to encourage granulation.
- **Hydrate** – to moisten the wound bed to encourage moist wound healing or debridement.
- **Protect** – to keep the tissue in the wound bed free from trauma and contamination.
- **Manage pain** – to ensure that the patient is comfortable.
- **Manage exudate** – to encourage a moist environment and protect the periwound skin.
- **Encourage granulation** – to support the formation of new capillaries.
- **Aid epithelialisation** – to encourage total wound closure by ensuring that epithelial cells cover the wound bed.
- **Reduce bacterial bioburden** – to minimise the risk of infection.

One of the main principles of wound management is moist wound healing, a concept first posited by Winter (1962) and which states that the wound bed must be kept moist using conventional dressings to encourage wound healing. While this principle was initially based on managing acute wounds, it has also been proven to be effective in managing chronic wounds (Hollinworth 2005). While the theory of wound bed preparation has largely superseded Winter’s (1962) work, ensuring that the wound is adequately hydrated is one of the cornerstones of modern wound care and an essential element of the TIME framework (Dowsett et al 2015a).

**Selecting an appropriate wound dressing**

The dressing selection process is influenced by the needs of the wound bed, for example whether it requires debridement, hydration, desloughing or the promotion of granulating tissue. Each dressing type has its own unique properties and the healthcare practitioner and patient should consult to choose the appropriate dressing to be used on the wound (Chamanga 2016). Types of dressing include passive dressings, interactive dressings and occlusive dressings (Table 2).

If the chronic wound continues to be resistant to treatment, the healthcare practitioner may also decide to refer the patient to a specialist. For example, if a patient presents with compromised blood flow to the lower limbs, they may benefit from a consultation with a healthcare professional in the vascular department.

**TIME OUT 5**

A 56-year-old patient with a history of hypertension, type 2 diabetes and peripheral vascular disease presents with a diabetic foot ulcer on their right heel that they have had for three months. The wound measures 3.5cm in length, 2.4cm in width and less than 0.5cm in depth. The wound bed consists of 50% necrotic material and 50% pale granulation tissue. The periwound skin is macerated and wet. The wound also exhibits malodour and thick exudate, indicating that it is critically colonised. Consider the following:

- What are your treatment aims?
- How would you prepare the wound bed?
- Which dressings would you consider using?
- How could you explain to a colleague what is occurring in the wound bed?

**TABLE 2. Types of dressing and their properties**

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive dressings</td>
<td>Foams, Films, Silicone</td>
<td>For low exudation and epithelialising wounds, Provide protection by covering the wound, Provide protection against dehydration</td>
</tr>
<tr>
<td>Interactive dressings</td>
<td>Alginites, Hydrocolloids, Hydrogels, Semi-permeable films, Some foams</td>
<td>For clean granulating wounds, Actively interact with the wound surface by either filling space to encourage granulation or resting on top of non-viable tissue to encourage wound debridement, Promote an optimal environment for wound healing, Provide protection against dehydration, Many, but not all, interactive dressings are semi-impermeable to moisture, which promotes moisture balance</td>
</tr>
<tr>
<td>Occlusive dressings</td>
<td>Hydrocolloids</td>
<td>Completely seal off the wound from the external environment, Occlusive</td>
</tr>
</tbody>
</table>

(Eaglstein 2001, Sussman 2014)
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Advanced interventions for chronic wounds

Biofilm removal
Some chronic wounds exhibit colonies of bacteria that live in communities known as biofilms (James et al 2008). Biofilms are known to impair healing in chronic wounds as well as demonstrating tolerance to antimicrobial therapies and phagocytic cells (Phillips et al 2010). Biofilms are a precursor to wound infection and they lead to the development of chronic wounds because they typically present in wounds stuck in the inflammatory phase exhibiting high levels of MMPs, which can be a result of chemical imbalance in the wound bed (Phillips et al 2010). Because of advances in technology and wound care research, irrigation solutions and gels that contain antimicrobial agents, for example antiseptics such as polyhexanide that are active against Gram-negative and Gram-positive bacteria, have been developed that clean, moisten and decontaminate chronic wounds, thereby reducing the bacterial load in the wound bed (Horrocks 2006, Chamanga et al 2015).

Larval therapy
Wound debridement is an essential aspect of the wound bed preparation process (Dowsett et al 2015a). In chronic wounds, this can be achieved using larval therapy (Chan et al 2007). This involves fly larvae being applied to the wound bed in a mesh pouch or free range. The larvae release an enzyme in their saliva that dissolves necrotic tissue, which is then ingested. Other debridement methods are available, such as autolytic debridement, where dressings are used to enhance the body’s natural rejection of necrotic tissue, or sharp debridement, where necrotic tissue is manually removed, but larval debridement is quick and precise since the larvae only ingest necrotic tissue (Wolff and Hansson 2003).

Debridement pads and cloths
NICE (2014) recognised monofilament pads as an effective wound debridement method. Debridement of chronic wounds using a monofilament pad removes dead or damaged tissue from the wound bed and can be undertaken in the community at relatively low cost (NICE 2014). Monofilament pads have also been found to be effective in breaking down biofilms in chronic wounds (Wolcott 2016, Morris et al 2017).

Pre-moistened single-use cloths are also available for chronic wound debridement and cleaning of the periwound skin, particularly in ulcers on the lower limbs (Young 2016). These cloths can remove necrotic material, moisten the wound bed and remove the necessity for healthcare practitioners to use buckets of water when cleansing patients’ leg ulcers in their own homes, for example.

Negative pressure wound therapy
Following successful wound debridement, the use of negative pressure wound therapy can be beneficial in the management of chronic wounds (Armstrong et al 2005). Negative pressure wound therapy uses a system of suction and dressings to provide negative pressure at the wound bed, thereby removing excess exudate, which can contain waste products such as high levels of MMPs. This encourages granulation and healthy vascularisation because of increased local blood flow, reduced oedema and reduced bacterial colonisation (Jones et al 2005).

Electrical stimulation
Houghton (2017) found that electrical stimulation therapy, where electrodes are placed on or around the wound and an electric current is supplied to the area, stimulates tissue repair and wound closure in chronic wounds. While electrical stimulation therapy is understood to activate the nerves and muscles of the wound bed, the exact scientific process is not fully understood. Electrical stimulation therapy can be expensive; therefore, an accurate diagnosis of the wound is required before its use is considered (Houghton 2017).

Dressings
As well as the dressings listed in Table 2, there are several innovative types of wound...
care dressings aimed specifically at treating chronic wounds (British National Formulary 2017). These contain a variety of antimicrobial agents including silver, polyhydrated ionogens, which aim to restore MMP ratios in chronic wounds (Pirayesh et al 2007), and protease-modulating dressings that may include, for example, nano-oligosaccharide factor, which is a synthesised component that is designed to inhibit protease activity (NICE 2016b, 2018).

**TIME OUT 6**
Reflect on a patient you have encountered in your practice with a chronic wound. Consider the treatments that were used and whether a more innovative treatment might have been used. What would be your rationale for choosing an innovative treatment, and what effect would you expect it to have on the wound bed? For example, how would a protease-modulating dressing effect the cellular composition of the wound bed?

**Conclusion**
Chronic wounds remain a challenge in clinical practice, and involve significant costs, both in terms of healthcare providers’ resources and patients’ quality of life. Chronic wounds usually develop because of intrinsic and/or extrinsic factors, which lead the wound to become stuck in one of the wound-healing phases, predominantly the inflammatory phase.

When managing a patient with a chronic wound, it is important that nurses perform a holistic assessment to identify any presenting factors that may lead to wound chronicity, including reviewing the patient’s medical history and undertaking tests that can indicate the presence of infection in the wound bed.

The healthcare practitioner should understand the biological changes that take place in chronic wounds so that they can prescribe appropriate therapy, which may include conventional dressings or innovative treatments such as protease-modulating dressings, negative pressure wound therapy or electrical stimulation therapy, depending on the objectives identified by the assessment. Healthcare practitioners should consider how any potential interventions will interact with the chronic wound bed, to ensure that cost-effective treatment is provided.

**TIME OUT 7**
Nurses are encouraged to apply the four themes of The Code (NMC 2015) to their professional practice. Consider how the management of chronic wounds relates to The Code.

**TIME OUT 8**
Now that you have completed the article, you might like to write a reflective account as part of your revalidation.

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Management of chronic wounds
TEST YOUR KNOWLEDGE BY COMPLETING THIS SELF-ASSESSMENT QUESTIONNAIRE 934

1. What is the definition of a chronic wound?
a) A wound that heals within three months □
b) A wound that fails to heal within a predicted timeframe □
c) A wound that cannot be treated □
d) A wound that occurs in patients who are at the end of life □

2. Cell types found in the healing wound bed include:
a) Proteases, neutrophils and macrophages □
b) Epidermal Langerhans cells □
c) Dendritic cells □
d) Microglial cells □

3. The role of platelets in haemostasis is to promote:
a) Angiogenesis □
b) Clotting □
c) Phagocytosis □
d) Re-epithelialisation □

4. Which of the following is not a phase in the normal wound-healing process?
a) Haemostasis □
b) Inflammation □
c) Debridement □
d) Proliferation □

5. Which of the following are features of a chronic wound?
a) Prolonged inflammation □
b) Infection □
c) Formation of microbial biofilms □
d) All of the above □

6. Inflamed tissue at the wound bed:
a) Inhibits the release of reactive oxygen species □
b) Results in under-production of matrix metalloproteinases □
c) Attracts neutrophils and macrophages □
d) Increases secretion of tissue inhibitor of metalloproteinases □

7. Which of the following is an intrinsic factor in the development of a chronic wound?
a) Medicines □
b) Age □
c) Alcohol consumption □
d) Smoking □

8. One extrinsic factor that may contribute to the development of a chronic wound is:
a) Gender □
b) Infection □
c) Stress □
d) Diabetes mellitus □

9. One of the physical observations that nurses can use to assess the patient’s wound status is:
a) Measuring the wound dimensions □
b) Regular blood pressure testing □
c) Monitoring fluid intake □
d) A pupillary light reflex test □

10. What is a biofilm?
a) A high burden of infection in the periwound skin □
b) A colony of bacteria □
c) The presence of microbials on the cell membrane □
d) A layer of necrotic tissue covering the wound bed □

This self-assessment questionnaire was compiled by Jason Beckford-Ball

How to complete this assessment
This self-assessment questionnaire will help you to test your knowledge. It comprises ten multiple choice questions that are broadly linked to the article starting on page 48. There is one correct answer to each question.

» You can test your subject knowledge by attempting the questions before reading the article, and then go back over them to see if you would answer any differently.

» You might like to read the article before trying the questions. The correct answers will be published in Nursing Standard on 21 March.

Subscribers making use of their RCNi Portfolio can complete this and other questionnaires online and save the result automatically. Alternatively, you can cut out this page and add it to your professional portfolio. Don’t forget to record the amount of time taken to complete it.

You may want to write a reflective account based on what you have learned. Visit rcni.com/reflective-account

Answers to SAQ 932 on Homelessness at the end of life, which appeared in the 28 February issue, are:
1. c 2. b 3. d 4. c 5. b 6. a 7. d 8. a 8. c 10. a

Answers to SAQ 933 on Testicular cancer, which appeared in the 7 March issue, are:
1. a 2. c 3. b 4. c 5. d 6. e 7. c 8. a 9. b 10. d