18 The Local Treatment: Methodology, Debridement and Wound Bed Preparation

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The Assessment

The local treatment of ulcers is based on a methodological approach that considers the type of lesion and any variables (infection, associated pain, localization, dimensions) that can be present at baseline, or it can occur subsequently. Therefore, a preliminary assessment is always necessary to develop an effective treatment.

The classification of upper and lower limb systemic sclerosis (SSc) ulcers [1, 2] defines the ulcer type and provides the fundamental elements to decide the type of local treatment (e.g. removal of calcinotic deposits in DU or the curettage of DPS) and also the information necessary to make a prognosis defining the risk of recurrences.

Ulcers and Pain

Ulcers are often a source of moderate/severe pain, which may cause functional impairment and deeply affect patient's health-related quality of life (HRQoL) [3]. Ulcer-related pain must be always analysed and classified (WUWHS classification, 2004) [4] (see Table 18.1).

Assessing skin ulcers' related pain is crucial to verify the effectiveness of the therapeutic approach and to plan a correct local treatment.

At baseline, the clinician must evaluate pain to decide an antalgic therapy which should be changed if the previous therapy was ineffective. An increased amount of necrotic tissue, infection and a not suitable dressing may be potential sources of pain. Therefore, the local approach should start by the removal of the dead or infected tissue. Moreover, an adequate dressing is mandatory to maintain the wound bed moist and protect the tissue. It is also important to assess the onset of critical ischaemia which can cause pain and need a systemic therapeutic approach to prevent its evolution to necrosis and/or gangrene.

During the change of the dressing, the detersion and the debridement of the wound bed, some procedural problems may be encountered. First, if the dressing is adherent to the wound bed, it is useful to use warm sterile saline solution to moist the attached medication and remove it gently. The use of medications that provide a warm moist environment without sticking to the wound bed is always recommended.

The detersion must be performed using warm (37 °C) sterile saline solution to avoid tissue thermal shock using a 10 ml syringe to reduce rinsing pressure on DU.

At least 15 min before debridement, the application of lidocaine/prilocaine ointments (cream 2.5%/2.5%) or gauze with lidocaine solution (2–4%) to control pain and to perform a safe and effective debridement is fundamental.

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Table 18.1 DU-related pain, classification, definitions and evaluation tools

Type of pain	Definition	Assessment tools
Background pain	Background pain can be described as a continuous sharp and/or throbbing sensation which is present at rest and is relatively constant. It is generally associated with DU aetiology and other local factors (ischaemia, infection, eventual reaction to a medication) A severe and intense pain spreading from the ulcer to the whole arm may indicate a critical infection	1. Tools for subjective evaluation VAS (visual analogue scale) NRS scale (numeric rating scale) 2. Tools for subjective evaluation suitable for children, cognitively impaired patients, subjects with speech and language disorders VRS Wong-Baker scale McGill questionnaire 3. Tools for objective evaluation FLACC scale (face, legs, activity, cry, consolability scale)
Episodic (breakthrough) pain	Transitory flare of pain generally occurring during the daily activities	
Procedural pain	Transitory pain occurring during a specific therapeutic procedure (dressing change, DU detersion, debridement)	

Instructions to Control DU-Related Pain

Background Pain

- Initiate/change antalgic therapy.
- Assess new onset of infection.
- Assess new onset of critical ischaemia.
- Evaluate RP severity and intensity (Raynaud's Condition Score – RCS) [5].
- Assess efficacy of local therapy (change type of medication/gauze).

Procedural Pain

During Dressing Change

- Remove gently the previous dressing using warm sterile saline solution.
- Use nonadhesive medications.
- Use hydrogel which hydrates viable tissue and protects cutaneous nerve endings.
- Assess efficacy of local therapy (change type of medication/gauze).

During DU Detersion

- Rinse and irrigate the ulcer with warm (37°C) sterile saline solution.
- Reduce rinsing pressure using 10 ml syringe.

Before Sharp Debridement

- Application of lidocaine/prilocaine ointments (cream 2.5%/2.5%)
- Application of gauze with lidocaine solution (2–4%)

Ulcer Dimension and Depth

The ulcer dimension should be monitored over time to assess the healing process. Experts agree on the fact that a reduction of wound area from 20% to 40% in 2–4 weeks of treatment is a sign of a good healing process [6].

However, due to the small DU dimensions, it is difficult to ensure a reliable measurement. Therefore, to assess the DU dimension, it is necessary to use photographic records with standard anatomical reference points and unit of measurement adequately defined. Photographic records can be stored and used for research purposes only with patient's written consent. Figure 18.1 reports DU measurement.

The following staging of ulcers has been proposed:

- Superficial: partial thickness skin loss involving epidermis (Fig. 18.2).
- Intermediate: full thickness skin loss involving damage to, or necrosis of, subcutaneous tissue that may extend down to, but not through, the underlying fascia (Fig. 18.3).
- Deep: full thickness skin loss with extensive destruction or damage to muscle down over the fascia to the bone. All the structures, tendon, joint capsule and bone are usually involved (Fig. 18.4).

All these types of ulcers must be considered as potentially critical due to the high risk of infection and the evolution to severe complications as necrosis and gangrene [1].

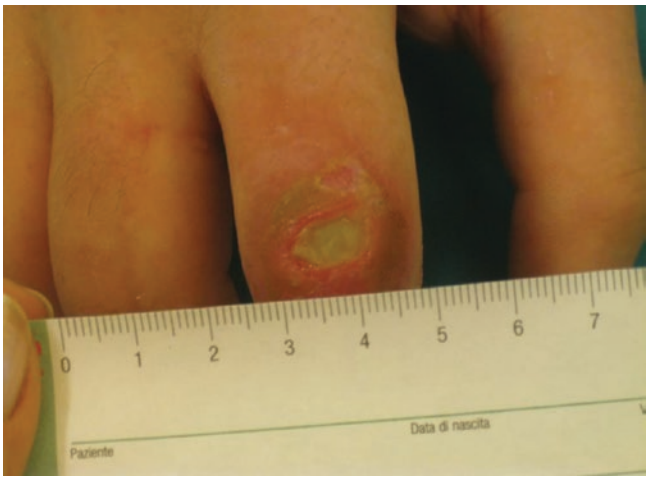

Fig. 18.1 DU measurement

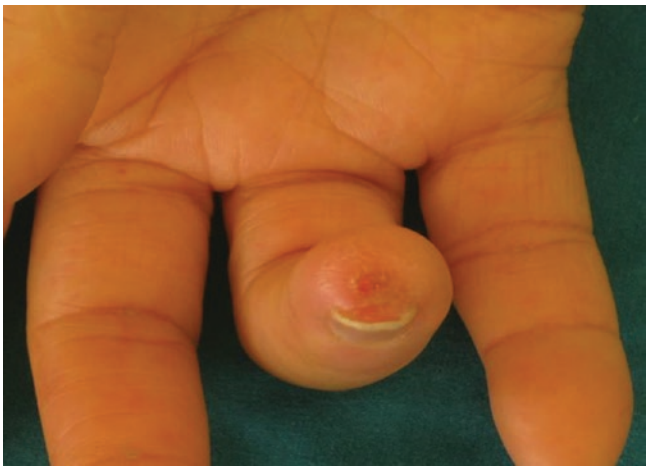

Fig. 18.2 Superficial – partial thickness skin loss involving the epidermis only

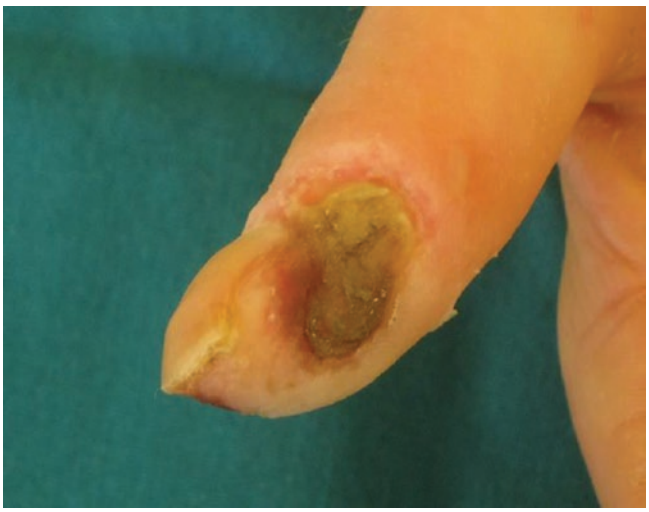

Fig. 18.3 Intermediate – full thickness skin loss involving necrosis of subcutaneous tissue

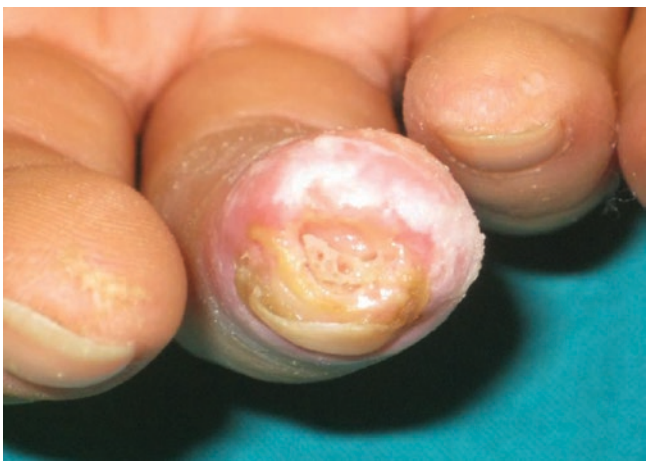

Fig. 18.4 Deep – full thickness skin loss down to the bone

The Wound Bed Preparation (WBP)

In SSc, the local therapy of ulcers is based on the principles of WBP, which has gained international recognition as a structured approach to the management of chronic wounds (a chronic wound is defined as a wound which lasts more than 6 weeks) [7]. The definition of WBP is "the management of an ulcer in order to accelerate endogenous healing or to facilitate the effectiveness of other therapeutic measures".

To explain the correct strategy to approach an ulcer, the acronym TIME was developed in 2002 by a group of experts as a practical guide to summarize the four main components of WBP [8]:

- *T*: *T*issue management
- *I*: Control of infection and inflammation
- *M*: *M*oisture imbalance
- *E*: Advancement of the epithelial edges of the wound

The TIME approach is a strategical framework which is a useful and practical tool to identify the main elements that should be considered to achieve a steady healing and to carry out a plan of care apt to promote wound healing.

Tissue Management "T"

The assessment of the tissue consists in a careful observation of the characteristics of the ulcer considering its bed, edges and the perilesional skin. The primary goal of this step is the identification of the main barriers to a steady healing that are the biofilm, the bioburden, the slough and the nonviable or deficient tissue (Table 18.2).

The treatment of tissue is carried out following two different steps:

1. The first step is *detersion* – the mechanical removal of dirt, cellular debris, necrotic tissue, remnants of previous dressings and other wastes present on the wound bed and on the surrounding skin [14, 15]. It can be performed by irrigating with a warm (37 °C) saline solution (NaCl 0.9%) and using a 35 ml syringe and 19 G needle for lower limb ulcers and a 10 ml syringe and a 19G needle cannula for all the other types of ulcers, modulating the strength applied on the plunger (Fig. 18.5).

Table 18.2 Barriers to healing in SSc cutaneous ulcers

Barriers to healing	Definition
Biofilm	A biofilm is defined as a structured conglomerate of microbial cells encompassed by polymer matrix produced by the host [9]. Fibrin, platelets or immunoglobulins may be present into the biofilm [10]
Bioburden	The concept of bioburden includes the following dimensions: the microbial load, the pathogenicity, the virulence and the diversity of the microorganisms across the wound bed [11]
Slough	Nonviable tissue which facilitates the development of biofilm [12]
Nonviable or deficient tissue	Ischaemic tissue, no longer viable [13]

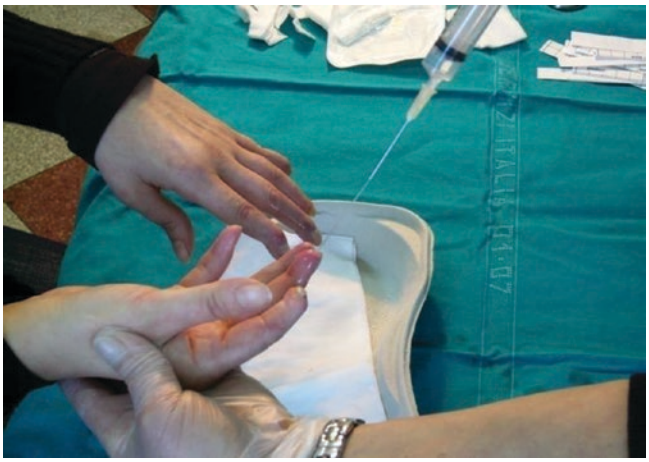

Fig. 18.5 Detersion of a fingertip digital ulcer in a SSc patient

Instructions for Detersion

- Detersion – irrigation of the wound with saline solution (NaCl 0.9%) and applying a pressure ranging from 8 to 15 psi (using a 35 ml syringe and a 19G needle). This procedure allows an efficient detersion without damaging the granulating tissue.
- The detersion may be extremely painful for SSc patients; in these situations it is mandatory to decrease remarkably the irrigating pressure. This is possible using a 10 ml syringe and a 19G needle cannula modulating the strength applied on the plunger.
- In order to avoid vasospastic attacks, the irrigating solution must be warmed (37°C).

2. The second step is *debridement* which is defined as follows: "The removal of necrotic material, eschar, nonviable tissue, infected tissue, slough, pus, foreign bodies, cellular debris, bone fragments or any other kind of bioburden from a wound in order to promote its healing" [8]. Thus, debridement mainly consists in the removal of nonviable material, foreign bodies and necrotic tissue from a wound. Surgical resection of viable tissue or surgical amputation is not included in the debridement procedure. Debridement procedure must be carried out also on wound edges and perilesional skin. There are five types of debridement:

- *Passive debridement* – It is based on the enhancement of the physiological and endogenous processes of debridement naturally occurring in a healing wound.
- *Active debridement* – It is carried out by a physician using specific surgical tools.
- *Selective debridement* – It consists on the selective removal of nonviable tissue, preserving viable material and granulating tissue.
- *Nonselective debridement* – It consists on the removal of healthy or/and nonviable tissue.
- *Maintenance debridement* [7] – In chronic wounds, in which the normal process of healing has been disrupted, the necrotic burden continually accumulates on the ulcer surface. In these cases, it may be more appropriate to perform regular or even continuous debridement. In SSc, the maintenance debridement is mandatory on fingertip DU, due to the continuous and fast production of bioburden.

The debridement is recommended in all types of SSc wounds. The assessment of the clinical features of a wound (e.g. presence/absence of biofilm, slough, infection, etc.) is essential to choose the adequate type of debridement. In addition many other factors have to be taken into account such as the patient's general health status, the ability of the caregiver and the presence and intensity of wound-related pain, patient's age and HRQoL [8].

Table 18.3 shows the most frequent methods of debridement in SSc. They are frequently performed in association. In Table 18.4, the instructions for an efficacious debridement are displayed.

Principal Goals of Debridement in SSc Ulcers

- Removing all barriers to healing
- Decreasing the amount of exudate
- Decreasing wound smell
- Reducing the risk of infection
- Decreasing the pain intensity (necrotic/nonviable tissue produces algogenic toxins)
- Promoting the proliferation of viable and granulating tissue
- Improving patient's HRQoL

Table 18.3 Methods of debridement in SSc ulcers

Methods of debridement	Tools (dressings/ surgical instruments)	Description
Autolytic debridement is a physiological and highly specific process by which endogenous proteolytic enzymes break down necrotic tissue. Every healing wound naturally experiences this kind of process in some level. This debridement method takes advantage of the moist and warm environment present on the interface between the wound bed and the dressing. Autolytic debridement doesn't cause pain or discomfort to the patient, but it is a slow method of nonviable tissue removal. Owing to this characteristic autolytic debridement is often combined with other types of debridement or in case of minimal production of bioburden [8, 16]	*Hydrogel*	Hydrated carboxymetil-cellulose polymer dressings, containing 90% water in a gel base, which helps regulate fluid exchange from the wound surface. Hydrogels are used in association with sharp debridement
	Hydrocolloids	Occlusive or semi-occlusive dressings composed of carboxymethyl cellulose, pectin, and elastomers. They jellify absorbing the wound exudate This type of dressing is rarely used in SSc, owing to its occlusive nature Hydrocolloids may cause discomfort and harm perilesional sclerotic skin
Sharp debridement – It is a minor surgical debridement which is usually carried out using scalpels, courgettes and scissors. It is a bedside procedure, which main goal is the removal of nonviable tissue. It is considered as a selective debridement, and it causes severe procedural pain. This problem could be overcome with the use of topically applied local anaesthetics (lidocaine), applied 30–45 min prior to debridement The real surgical debridement is a procedure performed by surgeons using general anaesthesia. It is the fastest way to remove wide patches of nonviable tissue especially in areas where there is a significant risk of lesion of major anatomical structures or in case of severe infections [17, 18]	*Scalpel and forceps*	It is used if the necrotic tissue is markedly separated from viable one This procedure must follow a thorough evaluation of patient's general health condition to rule out clotting disorders The tissue removed should be evaluated to assess eventual infectious processes The surgical site must be treated with antiseptics

Table 18.4 Instructions for debridement

Instructions	Rationale
A. Preliminary treatments and detersion	
1. Observe thoroughly the previous dressing	To notice and record signs of excessive exudation
2. Remove atraumatically the previous dressing, stretching the edges of the bandage in parallel to the skin. If the bandage was stuck to the perilesional skin and/or to the wound bed, it would be necessary to wet it with warm (37 °C) sterile saline solution or Ringer's lactate solution	Remove the dressing atraumatically
3. Clean the wound bed and the perilesional skin as summarized in *instructions for detersion* (above)	To remove foreign bodies, bioburden and exudate poorly adherent to the wound without damaging the granulating tissue
4. Get a compress with a gauze wet with 0.1% undecylenamidopropyl betaine/0.1% polyamide water solution for about 15 min	To remove the biofilm and prepare the wound for debridement
5. *Local analgesia* – it is recommended in case of sharp debridement. It would be useful in case of painful dressing removal. The antalgic effect must be verified before debridement The analgesic method is chosen based on the pain score previously recorded: 2.5% lidocaine/2.5% prilocaine cream compress (for 15 min) [19] Lidocaine hydrochloride, 2% water solution compress (for 15 min) [20] Lidocaine hydrochloride, 4% water solution compress (for 15 min)	To reduce the procedural pain Contraindications: allergy to the analgesic medication
B. Debridement	
Sharp debridement: the debridement is carried out by a sterile scalpel (blade 15 or 10) or a sterile courgette The wound bed and the perilesional skin must be both debrided (Fig. 18.6). Calcium deposits –*calcinosis* (stone, mousse, web) must be removed by sharp debridement (Fig. 18.7) A specific training is recommended to perform sharp debridement and to avoid damaging of granulating tissue Figure 18.8 shows a fingertip digital ulcer covered by slough. Figure 18.9 shows the same lesion after several sessions of local treatment	To remove necrotic tissue, slough, exudate and calcium deposits Sharp debridement must be performed on hyperkeratotic areas too (DPS) *This type of debridement must not be carried out in case of clotting disorders* *Sharp debridement is not recommended in the following situations*: When it's not possible the local analgesia If the patient can't tolerate the procedure itself Calcification in a wound creates chronic foreign body inflammatory reaction that contributes to a non-healing ulcer if calcific deposits are not removed. The removal of these deposits is essential to promote healing

Table 18.4 (continued)

Instructions	Rationale
Autolytic debridement: the type of primary dressing has to be chosen considering the amount of exudate and the dryness of the wound bed: Heavily exuding wounds: alginate dressing, hydrofibers Dried lesions/poorly exuding wounds/necrotic wounds: hydrogels, hydrocolloids The dressing has to be shaped based on the DU size	Autolytic debridement can be used combined with sharp debridement or as primary treatment Hydrogel is often applied to the wound bed after the sharp debridement to carry on the removal of bioburden (*maintenance debridement*) and to moisture and to keep the granulating tissue healthy A specific training is not necessary to perform autolytic debridement. It is an easy procedure that can be performed by a caregiver too
Secondary dressings: secondary dressing provides several important functions such as holding the primary dressing in the correct position, protecting the wound site from traumatic events or environmental factors (temperature/moisture) and camouflaging the dressing and providing treatment to the wound in synergy with primary dressing For DU it is important to apply protective secondary dressings (foams) A protective secondary dressing is shaped and based on the DU size; secondly we put on the top a TNT gauze stripe (15 × 100 mm), paying attention to keep the primary dressing in the correct place Cut three stripes of adhesive tape: n. 2 stripes 10 × 40 mm 8 (to place on the fingertip forming a cross) n. 1 stripe 10 × 100 mm (to cover the TNT gauze wrapping the fingertip). Figure 18.10 shows how to apply an adequate secondary dressing for a DU	Foams (secondary dressing) are useful to protect the DU from traumatic events and to reduce episodic pain too The TNT gauze protects the primary dressings and holds them in the correct position The secondary dressing must not be tight, in order to allow the digital perfusion The overall thickness of the dressing (primary +secondary dressing) has to be as thin as possible in order not to interfere with finger movements and to allow to wear protective gloves

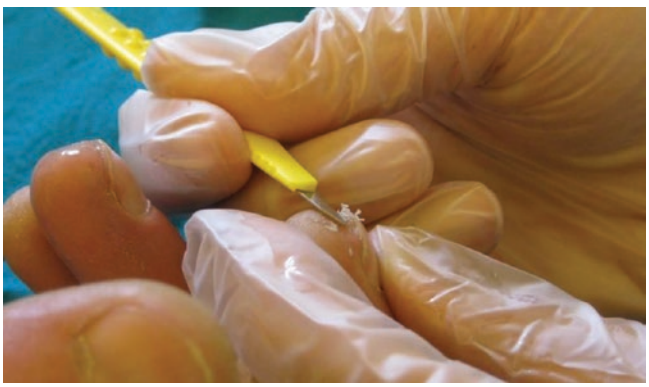

Fig. 18.6 Sharp debridement in a DU

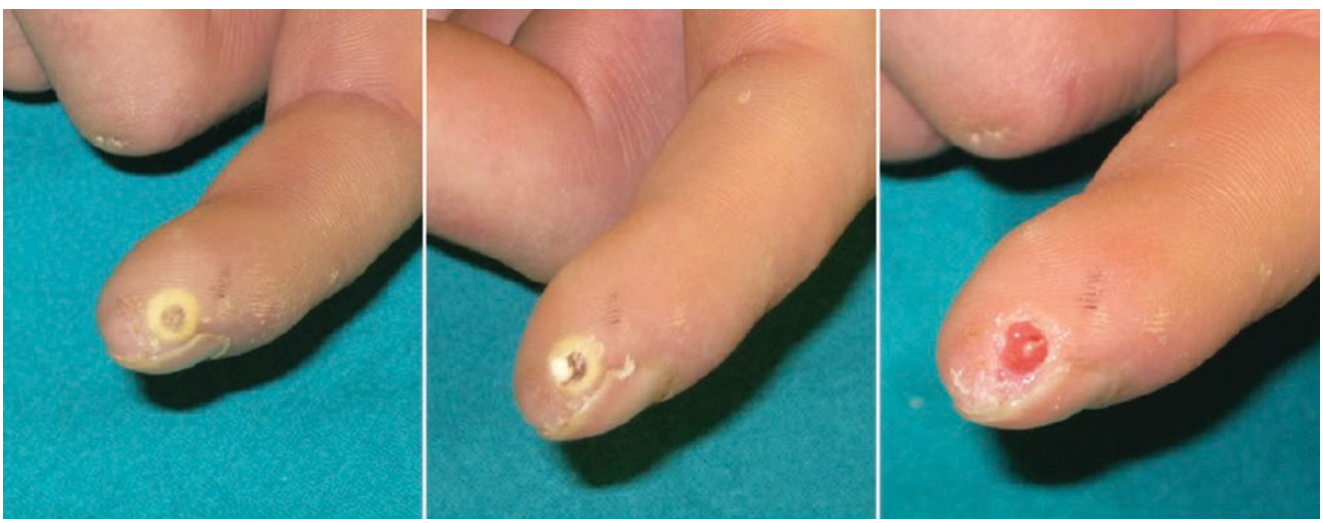

Fig. 18.7 Sharp debridement in a calcinosis

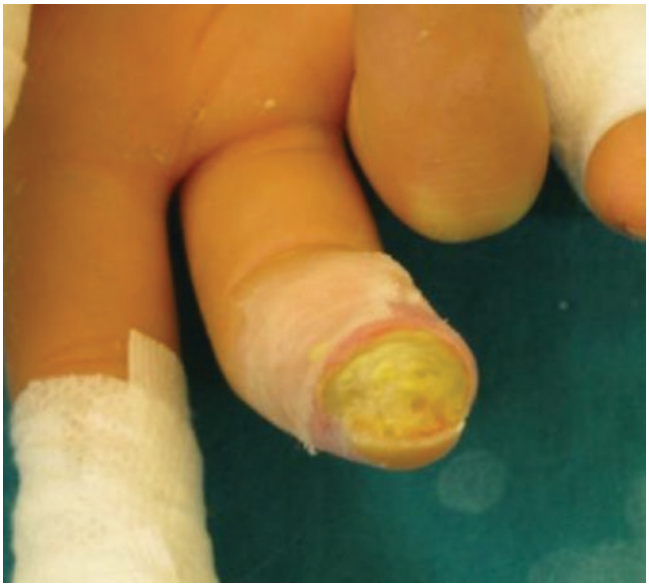

Fig. 18.8 DU covered by slough

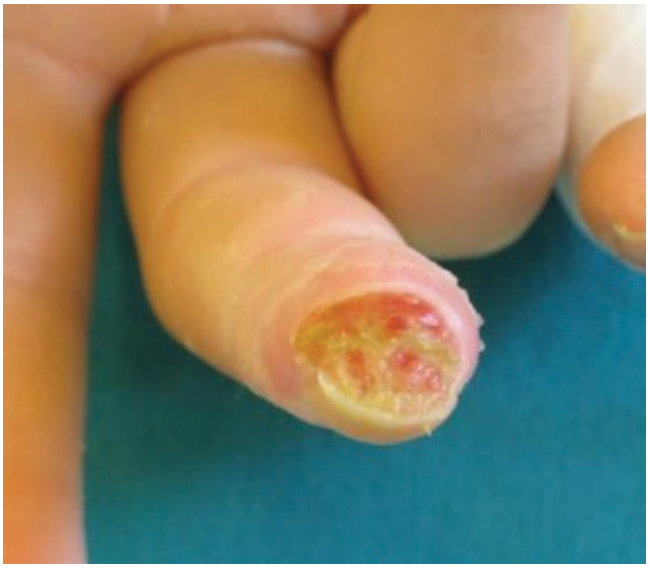

Fig. 18.9 DU after several sessions of local therapy based on sharp debridement and application of adequate dressings

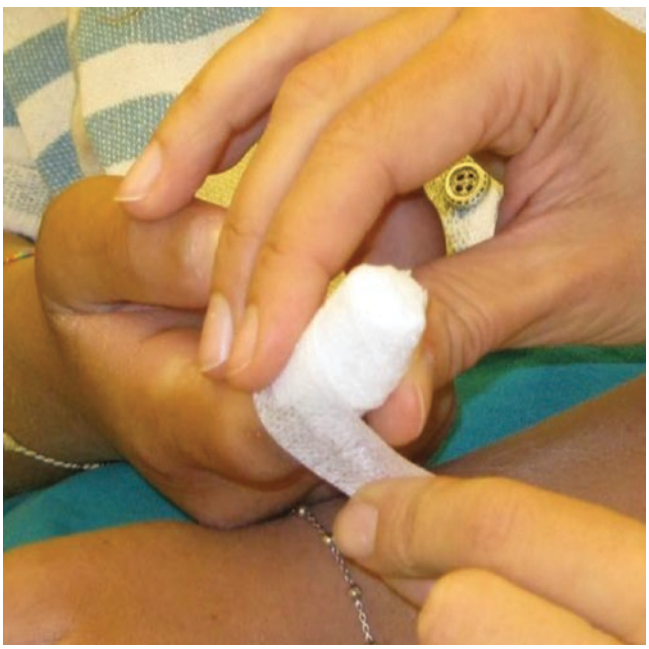

Fig. 18.10 Secondary dressing – application

Identification of Signs and Symptoms of Infection and Treatment "I"

In WBP, the correct approach to an inflamed or/an infected ulcer is pivotal to avoid the delay or even the block of the healing process.

Inflammation

It is a physiological response to tissue damage and it leads the way to wound healing. However, excessive or inappropriate inflammatory response – common in infection – can have serious consequences for the patient. Inflammation is not only related to physiological healing or to infection process. A persistent inflammation can lead to a stall of the healing process, favouring its chronicization and the block of wound healing. In chronic wounds, studies underline the fact that inflammation phase may become a disrupting event: in fact, fibroblasts from chronic wounds are dysfunctional; they show a premature senescence, and they are not responsive to growth factors. Fibrin on the wound bed seems to block the production of growth factors. The exudate of chronic wound exudate shows an increased activity of matrix metalloproteinases (MMPs), elastases and cytokines [19, 21, 22]. All these elements hinder the covering movement of the wound edges thus worsening the wound conditions.

Infection

Definition of "infection" is one of the most debated topics as there are many factors that take part in the development of infection where there is a critical bacterial wound colonization.

The infection process depends on the following:

- Bacterial burden (number of microorganism on the wound bed)
- Pathogen virulence (ability to produce toxins, invasiveness)
- Host resistance (capability to resist to bacterial growth through an effective immune response)

The presence of microorganism on wound's surface does not necessarily mean the presence of injury to the host. Contamination at wound site is common in any ulcer, and a constant number of bacteria are present on the wound bed usually not slowing the healing process. A real infection is a characterized by a critical bacterial colonization of the ulcer that can spread over the surrounding tissue: this is due to some concomitants, and usually this process follows a typical time continuum.

Biofilm

Most recent studies about the management of wound bed underlines the increasing importance of assessing and treating biofilms [23]. A biofilm is a complex microbial community, consisting of bacteria endowed in a protective matrix of sugars and proteins (glycocalyx). Biofilms are known to form on the surface of medical devices and are also found in wounds. Bacteria communities embedded within biofilm are partially protected from antimicrobials, environmental stresses and host's immune responses. The interaction between those microorganisms and host tissue is parasitical: bacteria get stable attachment and nutrition. Biofilms are a major contributing factor to chronic inflammatory changes in the wound bed. The chronic inflammation benefits the organisms in the biofilm which gains a higher resistance against antimicrobial and immune activity (phagocytosis, immune complex). Biofilm removal is fundamental to improve wound condition and to lead towards healing: it can be eradicated through debridement, though it can be treated with less invasive techniques such combinations of surfactant and products with antimicrobial activity.

Diagnosis

Diagnosis of infection in chronic skin ulcer is based upon bacteriological examination after the removal of biological material from the wound. Culture is indicated to identify the microorganisms and to guide antibiotic therapy. Swab culture is the most frequently employed method for confirming wound infection.

In everyday clinical practice, when infection is suspected, a prompt action must be taken, without waiting for the culture response, in order to prevent progression. The clinical evaluation of the lesion and the general conditions of the patient are sufficient to set a therapeutic plan on empirical basis in order to quickly stop the infection process and the deterioration of the wound. Afterwards, the result of the culture will be useful to confirm the infection and to set up an antimicrobial therapy.

Local Treatment of Infected Ulcer

Infections in DU have to be prevented or treated as soon as possible because they can lead to gangrene, osteomyelitis or self-amputation [24]. For this reason, local treatment in chronic wounds can be undertaken also as prevention or when an infection is probable because of the presence of typical signs and symptoms but without the evidence of an infection in the culture. Local therapy is based on broad-spectrum antimicrobial dressings and does not cause microbial resistance [25]. Table 18.5 reports the most frequent antimicrobial local treatments.

In SSc, DUs are often infected because of their specific localization (touching people, objects, surfaces). Poor patient's general conditions (malnutrition) and their hand disability increase the risk of infection. Moreover, the impairment of the immune response and sclerodactyly reduces the capacity to keep the hands clean [28]. In Table 18.6 the instructions for an efficacious management of infected ulcers are displayed.

Table 18.5 Main antimicrobial local treatments and their characteristics

Chlorine-based disinfectant (sodium hypochlorite in 0.05% water solution)	Before managing debridement it is useful to make a poultice with chlorine-based disinfectant for at least 10 min.
Antimicrobial dressings [26]	
1. Silver dressings	Silver has a long history of use as a topical antimicrobial in wound care Silver is a broad-spectrum antimicrobial. Although there is no scientific evidence supporting this recommendation, it is broadly used in everyday practice. Anyway some studies underline its efficacy in promoting the healing process [20]. Silver is incorporated into dressings either as nanocrystalline silver or ionized silver; this is the most common type of silver dressing
2. DACC dressings (dial carbamoyl chloride)	DACC encourages a natural hydrophobic interaction whereby hydrophobic organisms are attracted and irreversibly bound in the dressing hydrous environment. It seems that this process is effective on a variety of bacteria and some fungi. DACC dressing have a lighter antimicrobial effect than silver ones, but they have almost any cytotoxicity, and they cause no resistance
3. Iodine dressings	Iodine-based preparations have a long history of use in surgery and wound care. Some studies and a review demonstrate the effectiveness of cadexomer iodine in the healing of venous ulcers burdened by infection [27]
4. PHMB dressings	The polyhexamethylene biguanide (PHMB) is a broad-spectrum antimicrobial agent which is effective in both decreasing bacterial load and preventing bacterial penetration of the dressing. It also has a low cellular toxicity. PHMB dressings can be found as foams or gel

Table 18.6 Instructions for proper management of infected ulcers

Instructions	Rationale
1. Assessment of patient general health conditions noticing systemic signs and symptoms of infection/inflammation: appearance or increase of pain, uneasiness, fever	An infected ulcer can cause systemic effects. Suspect osteomyelitis in presence of fever, severe pain worsening with limb irradiation, oedema spread to the whole hand or leg and disability
2. Remove and check old dressing	Assess signs of moisture imbalance and changes in its components: wound smell/colour
3. Observe the ulcer in all its characteristics (signs and symptoms of topical infection/inflammation – Fig. 18.11) 4. *Wound bed*: granulating tissue fragile and hyperemic, unusual bleeding, change in wound bed colour, areas of necrosis, increasing fibrinous tissue, increased/purulent exudate. Notice possible presence of slime (opaque film spread all over the wound) 5. *Wound edges:* no progression nor viability of wound edges. Take account of undermined edges 6. *Perilesional skin*: rush, swelling and heat, tenderness 7. *In general terms:* healing delay and further deterioration of the wound	Appearance of these signs can be related to a phlogistic or infective process that has to be assessed and marked down in nursing clinical records
8. Measurement and photography of the ulcer	This allows comparing images and data before and after
9. Cleansing of the wound following the *instructions for detersion* (above)	Removal of dirt, shreds of previous dressings, debris and metabolic wastes
10. When there are clear signs of local or global infection (fever, aching of the whole limb, oedema, rush, purulent exudate, characteristic smell, functional impairment), perform a poultice for at least 10 min with a gauze soaked in a 0.025% hydrous solution of sodium hypochlorite. After the poultice removing the solution from wound bed with saline	Antisepsis method is chosen based on wound conditions: using sodium hypochlorite solution is the most aggressive method; it is chosen in case of clear infection. After application of this solution, it is important to wash it away from the wound bed through detersion, so that you can get rid of antiseptic residues that may have cytotoxic effects on granulation tissue

Table 18.6 (continued)

Instructions	Rationale
11. Analgesia and debridement by following the instructions in Table 18.4.	Eliminate/reduce procedural pain
12. Proper choice of dressing:	
(a) *Infected wound or systemic signs of infection* (*fever*, *pain widespread to the limb*, *oedema*, *redness*, *purulent exudate*, *characteristic odour*, *reduced functionality*) Semiquantitative swab. Ask the physicians for an eventual antibiotic therapy Apply iodine or silver dressings Warn the patient that mild local pain symptoms are common with silver dressings Choose combined dressings if necessary for the management of exudate and odour	When infection is highly suspected, the antibiotic therapy can be prescribed based upon the semiquantitative swab Silver and iodine have antimicrobic characteristics. Sometimes these dressings can lead to the development of resistance Gain information about eventual patient sensitivity to silver If iodine dressing is chosen, it is important to assess eventual thyroid diseases because of the possibility of systemic absorption of iodine Activated charcoal dressings reduce foul odour from the ulcer Restrict the use of silver dressings only in cases of overt infection to reduce the risk of resistance
(b) *Swollen wound with specific signs* (*increase in fibrin production and exudate*, *hypergranulation*, *bleeding*, *discoloration*) Recommendation of the following dressings: silver dressings, DACC dressings, PHMB dressings, honey or hypertonic saline dressings	These dressings have a less aggressive antimicrobic property but a higher tolerability
(c) *Not progressing wound without signs of infection/inflammation* Apply DACC or PHMB dressings but also saline or honey dressings	Often the delay in healing is the first sign of infection. Not healing wounds suspect infection; therefore, antimicrobic dressing can be used even if only for preventive purpose
1. Assess the need for a secondary dressing with absorbent or protective function.	Proper exudate management. Reducing risk of injuries and occasional pain
2. Wound closure following the instructions in Table 18.4	

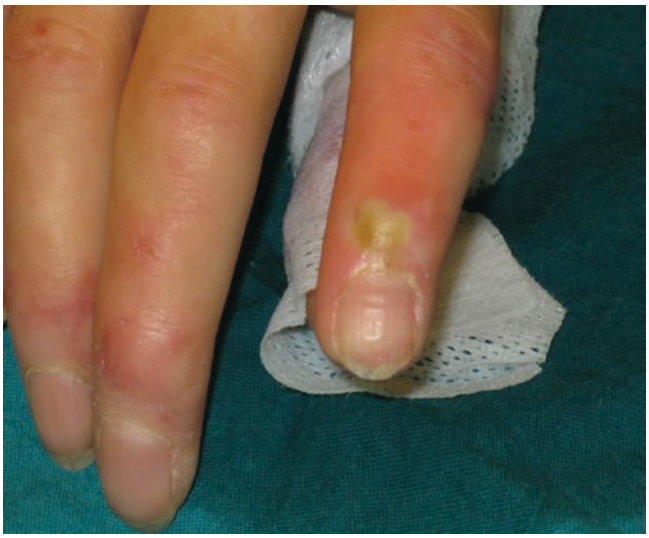

Fig. 18.11 A periungual-infected ulcer

Moisture Balance: Maceration or Dryness "M"

Managing exudate in chronic wounds is fundamental: wound epithelialization is stimulated by a moist environment, but an excess of fluid can macerate the healthy skin and delay the healing for the high content of proinflammatory cytokines and metalloproteinases that decrease the healing progression. The increased proteolytic activity of chronic wound exudate is thought to inhibit healing by damaging the wound bed, degrading the extracellular matrix and aggravating the integrity of the peri-wound skin, while the high levels of cytokines promote and prolong the chronic inflammatory response seen in these wounds.

The quantity and quality of wound exudate are associated with several factors:

- Ulcer surface
- Type of wound
- Stage in healing process
- Infection
- Oedema
- Local treatments

High exudate volume is one of the problems of chronic wounds that, with smell too, highly affect the patient quality of life. Excessive exudate production brings to a loss of protein, worsening malnutrition and increasing oedema. Moreover it increases the risk of infection as it favours the conditions for the replication of microorganisms. Wound leakage causes high distress in patients because it makes the wound smelly and it can soil clothes. Wound bed dryness is a relevant problem which blocks wound healing and is frequent in SSc ulcers where it may be due to low blood provision typical of microcirculation pathologies. Table 18.7 shows the adequate management of dry wounds. Table 18.8 shows how to manage the fluid balance in SSc ulcers both for the location, for the microvascular damage and for the dysfunction of the connective tissue (Table 18.9).

Table 18.7 The most frequent medications to treat dry ulcers

Hydrogel: hydrated carboxymetil –cellulose polymer dressings, containing 90% water in a gel base	Because of their structure, they have moisturizing properties. They also bring on the debridement of necrotic tissue
Hydrocolloid dressings (*occlusive dressings*): occlusive or semi-occlusive dressings, in contact with exudate, gel slowly	To be used in wounds not completely dehydrated. They keep the humidity at an optimum level. Contraindicated in case of infection
Paraffin gauze: gauze dressing impregnated with paraffin. These are water-repellent dressings; therefore, they do not absorb the exudate, and they keep it in contact with the wound bed	This kind of dressing is commonly used for the protection of the wound in the phase of re-epithelialization: at this step it is important to promote the maintenance of a moist environment. It is not recommended in case of ulcers "firm" or suspected of being infected
Polyurethane film: these dressings promote the moisture on the wound bed	They are impermeable to liquids but not to gases

Table 18.8 Instructions to balance fluid

Instructions	Rationale
1. Remove the previous dressing. Assess the quantity and quality of exudate	Observe old dressing: you can notice if it has been a good choice An hyperexudating wound could soak the dressing leading to liquid leakage and edges maceration In case of a dry wound bed, the dressing could adhere to the ulcer, and the removal has to be cautious; it is recommended to irrigate with saline
2. Choosing the dressing that is appropriate to the quantity/quality of exudate	Effective management of exudate

Table 18.9 Instructions to assess and treat the lesion edges and the perilesional skin in scleroderma ulcers

Instructions	Rationale
Assess the functionality of the edges: Measure the area of lesion to check if re-epithelialization is progressing (see instructions in *ulcer dimension and depth* section) Observe the ratios of new epithelium to granulation tissue, the outline of the edge in relation to the wound bed Observe the morphological characteristics of the new epithelium (hyperproliferation of the edges, discoloration and fragility of the new tissue) Detect and point out the presence of hyperkeratosis in the edge	Monitor the healing process advancement In the DU the survey of the area may be difficult owing to the small size of the lesion
Assess the perilesional skin: its colour, temperature, dryness/maceration, integrity, pain 1. Interventions on the edges: Removal of the nonvital tissue which blocks re-epithelialization and maintains inflammation (debridement of the edges) Protection of wound edges from maceration or from agents attacking the new epithelium (collagenase-based preparations, sticking plaster) Promotion of the re-epithelialization process with dressings containing metalloprotease-modulating agents, hyaluronic acid, purified collagen 2. Interventions on the skin: protection and hydration	Detect anomalies in the perilesional skin Create the environment which most favours wound closure The application of ointment containing vitamin e makes the skin elastic and trophic and appears to reduce recovery time [34]

Epidermis and Epithelial Edges "E"

The evolution of the healing process is shown by the growth of the epithelial edges. Assessing the characteristics of the epithelial growth allows understanding whether the ulcer is moving or is "blocked" into the state of chronic lesion. In a healing ulcer, actively proliferating keratinocytes form a line which progressively degrades in the bed made up of ripe granulation tissue. In chronic ulcers with a reduced tendency to recovery, epithelial cells often present phenotypic alterations and a reduced capacity of proliferation and migration [29]. Frequently, the chronic wound edge appears thickened with a typical "clifflike" outline. In addition, hyperproliferation of the edges interfering with the normal cell migration on the wound bed may be observed [30]. The hyperproliferation might be due to the inhibition of apoptosis (programmed cellular death) of keratinocytes and fibroblast [9].

The assessment of the outline of the edges has an important diagnostic value in particular when the edges do not adhere to the wound bed and the wound closure does not take place. The "undermining" of the edges should be always checked out following the "clock" method: the depth of the edges is probed clockwise with a sterile swab along the whole ulcer perimeter [31].

Digital pitting scars (DPS) are frequent and may manifest in the form of microareas of pinhole-sized depression and corneous deposit. The DU secondary to DPS often presents phenomena of undermining as well as a marked thickening and hardening of edges and perilesional skin.

The functionality of the edges also depends from the trophism and conditions of perilesional skin. For the perilesional skin, the following aspects are considered:

- Colour: red/erythematous skin (infection/inflammation), pale skin (ischemia), yellowish skin (hyperkeratosis), cyanotic skin (hypoperfusion)
- Temperature: warm skin (infection/inflammation), cold skin (hypoperfusion)
- Dryness: callosity, hyperkeratosis, hardening
- Maceration: white-greyish skin, softening, wrinkling
- Integrity: epithelial stripping, microlesions (skin tear)
- Pain and tenderness

Education of SSc Patients Affected by Ulcers

The optimal medical strategy for an SSc patient affected by ulcers includes a local and a systemic approach. This synergism promotes skin perfusion and trophism leading to a marked improvement of the patient's condition and to the ulcers' healing.

Nevertheless, to assure lasting results and to properly manage chronic wounds, it is necessary to achieve full patient participation and adherence to the treatments. This means that the clinicians must provide therapeutic educational interventions about dressing, protection of the extremities, self-management and measures to prevent the onset of new DUs. The therapeutic education process includes a thorough evaluation of the patient and its caregivers to assess their skills in self-management.

Basic instructions for skin care and DU prevention and treatment are listed below. These basic skills must be provided to patients and their caregivers.

Moreover the therapeutic education must be focused on the practical skills for DU self-management. Information materials (brochures, videos and educative sessions) could be extremely useful.

A direct helpline led by rheumatology nurses specialized in wound care allows home dweller patient to manage DU treatment and to recognize severe complications on time. Information and support about DU prevention and systemic therapy are given if necessary.

All those measures allow patients' active involvement in DU care and prevention to reduce hospital admission costs.

Life-Style Modifications for SSc Patients

- Wear gloves to reduce the intensity and the frequency of RP attacks when the temperature is cold (below 20 °C).
- Use cotton gloves in warm season too if the temperature is below 20 °C or in air-conditioned rooms [32].
- Protect dressings and medications on DUs using PVC or latex gloves to keep them clean, dry and in the correct position.
- It is mandatory to keep the hands clean.
- Check your hands' conditions daily in order to point out dyschromic areas or any signs of inflammation. Inform wound care nurses about:
  - RP frequency, duration and related pain
  - Itch, erythema or any other kind of cutaneous manifestation
- Don't smoke and don't assume vasoconstrictive agents (caffeine) [33].
- Keep the skin moisturized (with ointments/creams).
- Don't use aggressive soaps or detergents.

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