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Nerds and Stonees in Chronic Wounds: Clinical Application, Diagnostic Limitations, and Therapeutic Significance

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ABSTRACT

Introduction: *Chronic wound infections pose a significant clinical challenge due to delayed healing, tissue damage, the potential spread of infection, and systemic complications. Accurate differentiation between contamination, colonization, local infection, and spreading or systemic infection is essential for appropriate clinical management and the rational use of antimicrobial agents. A positive microbiological culture alone does not confirm clinical infection.*

Aim: *To evaluate the clinical relevance, diagnostic validity, and limitations of the NERDS and STONEES mnemonics in the assessment of chronic wound infections, considering historical evidence, the 2026 International Wound Infection Institute (IWII) consensus, current IWGDF/IDSA recommendations, and recent studies on biofilm diagnosis.*

Results: *NERDS and STONEES provide structured approaches to recognizing clinical signs of infection in hard-to-heal and chronic wounds. NERDS primarily identifies signs associated with delayed healing and changes in the wound bed, whereas STONEES highlights findings suggestive of more pronounced, deeper, or spreading infection. Neither the presence of three or more signs nor any individual finding should be considered an independent diagnostic criterion. Clinical interpretation requires consideration of wound etiology, vascular status, and the patient's overall condition. Comprehensive assessment may include clinical examination, microbiological testing, imaging, differential diagnosis, and evaluation of biofilm-related findings. Management should be individualized and may involve topical treatments, systemic antibiotics when indicated, treatment of the underlying cause, and urgent referral in cases of severe or spreading infection.*

Conclusion: *NERDS and STONEES are useful clinical aids for the systematic assessment of chronic wound infections but should not replace comprehensive clinical judgment or established diagnostic criteria. Integrating these mnemonics with current evidence-based guidelines and individualized patient assessment may support more accurate diagnosis, appropriate antimicrobial use, and improved wound management.*

Keywords
Chronic wounds, Wound infection, NERDS, STONES, STONEES, Biofilm, Clinical signs, Osteomyelitis, Diabetic foot, Antimicrobial therapy.

Abbreviations
IWII: International Wound Infection Institute; IWGDF: International Working Group on the Diabetic Foot; IDSA: Infectious Diseases Society of America; NICE: National Institute for Health and Care Excellence; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; MRI: magnetic resonance imaging; ABI: ankle-brachial index.

Introduction
Chronic wound infection is a significant clinical problem that can delay healing, damage surrounding tissues, and, if it spreads, cause serious complications. Clinical assessment relies primarily on recognizing characteristic signs and symptoms while considering the type and condition of the wound, the patient's general health, and factors that impair healing or increase the risk of infection spreading.

The NERDS and STONES mnemonic systems, including the expanded STONEES version, are used to organize and support clinical assessment of chronic wounds. The letters of these acronyms correspond to specific clinical signs suggesting increased bacterial burden or local wound infection. These systems are consistent with the Wound Bed Preparation concept, developed with contributions from Kevin Y. Woo and colleagues. The approaches were first described by Sibbald, Woo, and Ayello [1]; subsequently, Woo and Sibbald investigated the diagnostic characteristics of the included clinical signs in a study involving 112 patients [2]. The mnemonics support clinical judgment but do not replace comprehensive wound assessment and should not be used alone to diagnose infection.

The fourth edition of the International Wound Infection Institute (IWII) consensus, published in 2026, describes a dynamic continuum: contamination, colonization, local infection (with covert/subtle and overt signs), spreading infection, and systemic infection. NERDS and STONEES are complementary mnemonics, not equivalents of this continuum. High bacterial burden and clinical infection are not interchangeable concepts; diagnosis is based primarily on clinical signs, taking patient- and wound-specific characteristics into account [3,4].

This article is a narrative clinical review. References were purposively selected from the original publications describing the mnemonics, international consensus documents and clinical guidelines, and recent reviews and studies available through October 26, 2026. It is not a systematic review or meta-analysis.

NERDS: Clinical Signs of Increased Superficial Bacterial Burden
Definition and Clinical Significance
NERDS is a mnemonic used in hard-to-heal and chronic wounds to identify adverse clinical changes historically associated with increased superficial bacterial burden. The acronym comprises five signs: Nonhealing, increased Exudate, Red friable tissue, Debris, and Smell (malodor).

These signs were described in the context of clinical assessment of bacterial burden and infection in chronic wounds [1,2]. Their presence may indicate the need for a more detailed assessment of the wound bed and reconsideration of the current treatment approach. Importantly, however, NERDS does not independently confirm superficial infection, because the individual signs may also arise from noninfectious factors associated with wound etiology, the local wound environment, and the patient's overall condition.

It is particularly important not to conflate the terms “microbial burden,” “biofilm,” and “infection.” The number of microorganisms in a specimen does not, in itself, determine their pathogenicity or the tissue response; nor can biofilm be reliably identified from the wound's appearance alone [3,5,6].

Clinical Characteristics of the Signs
N — Nonhealing (a nonhealing or slow-healing wound)
Failure to make the expected progress toward healing is an important clinical warning sign. It may manifest as a lack of reduction in wound area, inadequate formation of viable granulation tissue, or prolonged persistence of the inflammatory phase. However, nonhealing is not specific to infection. Potential causes include arterial insufficiency, venous hypertension, edema, repeated trauma, inadequate pressure offloading, malnutrition, and poor glycemic control. Assessment must therefore establish the underlying wound etiology and identify factors that impede tissue repair [3,7].

E — Exudate (wound exudate)
Exudate is fluid released from the wound surface; its volume and characteristics may change during healing. An increase in exudate, especially when accompanied by adverse wound-bed changes, may suggest increased bacterial burden or infection. However, heavy exudation may also be associated with venous hypertension, edema, or other local and systemic factors. Accordingly, exudate volume, consistency, color, and odor should be interpreted within the overall clinical picture [2,3,7].

R — Red friable tissue (red, friable granulation tissue that bleeds easily)
Healthy granulation tissue is generally pink to red and gradually fills the wound defect. During an unfavorable course, it may become excessively friable, easily traumatized, and prone to bleeding with minimal contact. Such changes may occur with an increased bacterial burden but are not specific to infection. Traumatic wound manipulation, excessive moisture, and other local factors may also contribute. Assessment of granulation tissue should therefore be combined with monitoring for other signs of inflammation and impaired healing [1-3].

D — Debris (tissue debris and wound-bed deposits)

Fibrinous deposits, nonviable tissue, and other debris may complicate assessment of the wound bed and impede healing. Biofilm may also develop in chronic wounds: an organized microbial community surrounded by an extracellular matrix that makes microbial control more difficult. However, visible deposits do not establish the presence of biofilm or infection. The need for cleansing and debridement is determined individually according to wound type and condition, tissue viability, perfusion, and any contraindications [3].

Visible fibrin or slough is not evidence of biofilm. An international Delphi consensus published in 2025 identified 11 possible clinical indicators, including refractory nonhealing, poor-quality granulation tissue, and recurrent inflammation; however, these reflect expert agreement rather than a validated diagnostic test [6].

S — Smell (malodor)

Malodor may be associated with microbial activity, exudate accumulation, and nonviable tissue. It may change after wound cleansing or a dressing change. Odor alone does not establish infection, as it can be influenced by retained exudate, necrotic tissue, and dressing characteristics. Its clinical significance increases when it is new or worsening and occurs alongside other adverse changes, such as increasing pain, erythema, local warmth, increased exudate, or deteriorating healing [3,7].

Clinical Application and Interpretation of NERDS

In the historical literature, the presence of three or more NERDS signs has been used as a threshold for increased suspicion of superficial bacterial burden [1,2]. This threshold has not been independently validated for diagnosing clinical infection and is insufficient to justify systemic antibiotic treatment. In contemporary practice, wound progression, pain, peripheral perfusion, and the patient's condition carry more weight than a mechanical sign count [3,5].

When several NERDS signs are present, a comprehensive reassessment of the wound is appropriate, including:

- Measurement and documentation of wound area, depth, and changes over time;
- Assessment of exudate volume and characteristics;
- Description of granulation tissue, deposits, and nonviable tissue;
- Assessment for pain, erythema, local warmth, edema, and other signs of local inflammation;
- Analysis of the causes of delayed healing and the effectiveness of treatment to date;
- Evaluation of the need for cleansing, debridement, a dressing change, or additional diagnostic investigations [2,3,7].

Treatment should be tailored to the identified causes of impaired healing and the clinical evidence for or against infection. In the absence of convincing signs of infection, systemic antibiotics should not be prescribed automatically on the basis of NERDS alone. Where clinically indicated, topical antiseptics or antimicrobial dressings may be considered; their selection should be based on individual patient assessment, wound characteristics, and the available scientific evidence [3,7].

In summary, NERDS is an adjunctive tool for structuring clinical observation and identifying chronic wounds with signs of increased bacterial burden or impaired healing. Its principal value lies in prompting systematic reassessment rather than independently establishing a diagnosis of infection.

Stones and Stonees: Clinical Signs Suggestive of Deep or Spreading Wound Infection

Definition and Terminology

The STONES acronym was described first [1] and the expanded form STONEES has been used in subsequent publications [2,3]. In this review, STONEES refers to seven features suggestive of more pronounced local inflammation, possible deeper involvement, and/or spreading infection. Their presence does not in itself prove tissue invasion, osteomyelitis, or sepsis. The signs are:

- S — Size increasing: an increase in wound size.
- T — Temperature increased: increased local temperature of the skin surrounding the wound.
- O — Os, probes to or exposed bone: visible bone or bone reached during probing by a qualified healthcare professional.
- N — New areas of breakdown: development of new areas of tissue breakdown.
- E — Exudate increased: an increase in wound exudate.
- E — Erythema/Edema: erythema and/or edema of the surrounding tissues.
- S — Smell: wound malodor.

STONEES is an adjunctive clinical guide, not an independent diagnostic test. Individual signs, or combinations thereof, may raise suspicion of infection but do not independently confirm deep infection, osteomyelitis, or sepsis. Interpretation must consider the wound's etiology and location, vascular status, the patient's overall condition, and other clinical findings [1-3].

Clinical Characteristics of the Signs

S — Size increasing (increasing wound size)

An increase in wound area or depth despite appropriate care may indicate worsening of the local process. It is particularly important to determine whether new areas of tissue destruction have appeared or whether changes are extending beyond the original wound margins. However, this finding is not specific to infection, as it may also result from ischemia, venous hypertension, prolonged pressure, repeated trauma, or inadequate treatment. Wound size and depth should therefore be measured and documented regularly, with their progression interpreted in the context of other clinical findings [3,7].

T — Temperature increased (increased local temperature)

Warmth of the skin and tissues surrounding the wound may reflect a local inflammatory response and suggest infection. It is more diagnostically informative when accompanied by erythema, edema, increasing pain, or progressive spread of the changes. However,

local warmth is not specific to infection, and its absence does not rule infection out, particularly in patients with impaired circulation or an altered inflammatory response. This sign should therefore be assessed alongside other local and systemic manifestations [3,7].

O — Os, probes to or exposed bone (exposed bone or a positive probe-to-bone finding)

Visible bone or contact with bone on an appropriately performed probe-to-bone test is an important clinical finding, particularly in chronic foot ulcers in patients with diabetes. It increases suspicion of deep involvement and possible osteomyelitis but does not independently prove bone infection. When clinically indicated, further assessment and appropriate diagnostic investigations are required, potentially including inflammatory markers, plain radiographs, magnetic resonance imaging, and, in selected cases, microbiological or histological examination of a bone specimen [3,7].

Probing should be performed by a trained healthcare professional using the appropriate technique and only when indicated. Patients should not attempt to probe their own wounds.

N — New areas of breakdown (new areas of tissue breakdown)

The appearance of new areas of necrosis, tissue destruction, or additional ulcerative defects may indicate progression of the underlying pathological process. When these changes develop rapidly or are accompanied by increasing pain, erythema, edema, or systemic malaise, prompt clinical assessment for deep or spreading infection is necessary. The differential assessment must also consider other causes of tissue damage, such as ischemia, pressure, and repeated trauma [3,7].

E — Exudate increased (increased wound exudate)

A substantial increase in exudate or a change in its characteristics may indicate wound deterioration. Cloudy or purulent-appearing discharge, particularly when accompanied by inflammatory manifestations, warrants clinical reassessment. However, increased exudate may also be associated with edema, venous hypertension, or other factors. The color, consistency, and odor of the discharge do not reliably identify the causative organism; the need for microbiological testing must therefore be determined from the overall clinical presentation [3,7].

E — Erythema/Edema (erythema and/or edema)

Erythema and edema of the surrounding tissues may reflect local inflammation or spread of an infectious process beyond the wound margins. Progression and expansion of erythema, increasing tenderness, and the development of lymphangitis are particularly concerning. These findings require cautious interpretation, as edema and erythema may also result from venous stasis, contact dermatitis, or other noninfectious inflammatory conditions [3,7].

S — Smell (malodor)

Malodor may be associated with bacterial activity, exudate accumulation, and nonviable tissue. In isolation, it cannot establish either the presence or the severity of infection. Its clinical significance increases when it is new or worsening in parallel with wound enlargement, necrosis, changes in exudate, or other local and systemic manifestations [3,7].

In people with diabetes, peripheral neuropathy, immunosuppression, or significant ischemia, classic signs of inflammation may be attenuated. The appearance of erythema may vary with skin tone; comparison with baseline findings, palpation, pain, local changes, perfusion, and systemic symptoms are therefore important [3,4].

Clinical Application and Interpretation of STONEES

The presence of several STONEES signs should prompt a more detailed assessment of the wound and surrounding tissues. In published descriptions of the mnemonics, three or more signs are considered a clinical indicator of increased suspicion of infection [1,2]. However, this threshold must not be regarded as a universally validated diagnostic criterion for deep infection, osteomyelitis, or sepsis. When convincing signs of progressive infection are present, action should not be delayed until a specified number of criteria has been met.

Clinical reassessment may include

In the original descriptions, a threshold of three or more signs was used as an indicator of heightened suspicion of infection [1,2]. However, a combination of signs does not constitute a universally applicable diagnostic scoring scale; in the presence of increasing pain, spreading erythema, systemic organ dysfunction, or suspected necrotizing infection, clinicians should not wait for a particular score to be reached [3,4].

- Assessment of local temperature, erythema, edema, pain, and the extent of the changes;
- Description of exudate volume and characteristics, necrosis, and new areas of tissue destruction;
- Assessment of blood supply, underlying disease, and factors that impede healing;
- Evaluation of the need for laboratory tests, microbiological sampling, and imaging when deep involvement or osteomyelitis is suspected;
- Consultation with an appropriate specialist when the clinical picture suggests deep infection, a need for surgical intervention, or bone involvement [3,7].

Rapidly progressive erythema, severe pain or pain disproportionate to visible findings, rapidly spreading tissue damage, systemic malaise, confusion, or other signs of organ dysfunction warrant emergency medical assessment. For confirmed or strongly suspected infection, treatment is determined by severity and extent and may include systemic antimicrobial therapy and surgical source control when indicated [3,7].

In summary, STONEES supports the systematic recognition of clinical changes that may signal deterioration, deeper involvement, or spreading infection in chronic wounds. Its value lies in prompting timely clinical reassessment and appropriate diagnostic and therapeutic measures, rather than independently confirming or excluding infection.

Comparison of NERDS and STONEES

The NERDS and STONEES mnemonics support systematic clinical assessment of chronic wounds by drawing attention to distinct but partially overlapping groups of signs. NERDS is used to recognize features associated with increased bacterial burden and impaired healing, whereas STONEES emphasizes signs that may raise suspicion of deeper involvement or progressive infection [1-3].

The principal difference between these systems lies in their clinical focus, not in a categorical distinction between uninfected and infected wounds. Some signs, including increased exudate and malodor, occur in both mnemonics. Their interpretation must therefore be based on combinations of findings, the wound's progression, and the patient's overall condition (Table 1).

Diagnostic Value and Limitations

In the cross-sectional study by Woo and Sibbald involving 112 patients, a combination of three clinical signs was compared with semiquantitative wound-swab cultures. A sensitivity of 73.3% and specificity of 80.5% were reported for one category of bacterial growth, and 90% and 69.4%, respectively, for another category [2]. These estimates describe the association with the microbiological outcome defined in that study, not diagnostic accuracy for clinical infection or osteomyelitis.

The reference method used, single-time-point cross-sectional design, limited study population, and differences between microbial burden, biofilm, and infection restrict the generalizability of the findings. A 2026 systematic review rated the study's methodological quality as low and emphasized the absence of a validated noninvasive scale for detecting biofilm [5].

Therefore, three or more signs may indicate the need for more detailed clinical assessment but do not independently confirm infection or justify automatic antibiotic prescribing. Similarly, failing to reach a specified sign count does not exclude infection when convincing clinical evidence is present.

Practical Application of Both Mnemonics

NERDS and STONEES can be used as complementary tools within comprehensive chronic wound assessment. When NERDS signs are present, attention is directed to the wound bed, quality of granulation tissue, exudate, deposits, and possible causes of delayed healing. With STONEES signs, priority shifts to assessing the extent of local changes, wound depth, and the likelihood of a more serious infectious complication.

Clinical management must be individualized and may include wound measurement and documentation, assessment of perfusion and surrounding tissues, correction of factors impairing healing, and further investigations when indicated. Microbiological specimens should be obtained appropriately when the results are likely to affect treatment decisions. Imaging is considered when an abscess, osteomyelitis, or other deep involvement is suspected [3,7].

Clinical evidence of rapidly progressive infection, severe pain or pain disproportionate to visible findings, spreading erythema, or systemic deterioration requires prompt medical assessment, irrespective of the number of identified mnemonic signs.

In conclusion, NERDS and STONEES have complementary roles in the systematic monitoring of chronic wounds. They help recognize adverse changes and structure clinical reasoning but do not replace comprehensive examination, specialist judgment, or appropriate diagnostic investigations. Their proper use may facilitate timely identification of complications and individualized treatment.

Scientific Evidence and Diagnostic Limitations

The available scientific evidence highlights the need to interpret clinical signs in chronic wounds within a comprehensive patient assessment. As discussed in Section 4.1, NERDS and STONEES help organize clinical findings but cannot independently confirm infection or determine whether antibiotic treatment is required. Their practical application must reflect limitations of the evidence

Table 1: Comparison of NERDS and STONEES in the Clinical Assessment of Chronic Wounds.

Characteristic	NERDS	STONEES
Primary focus	Signs of increased bacterial burden and impaired healing	Signs raising suspicion of deeper involvement or spreading infection
Number of signs	Five	Seven
Main clinical findings	Nonhealing, increased exudate, red friable granulation tissue that bleeds easily, tissue debris and deposits, malodor	Increasing wound size, local warmth, exposed bone or a positive probe-to-bone finding, new areas of breakdown, increased exudate, erythema and/or edema, malodor
Primary clinical significance	Prompts reassessment of the wound bed, local care, and factors that impair healing	Prompts assessment for deeper or progressive infection and possible complications
Additional investigations	Determined by clinical findings; not ordered automatically on the basis of the mnemonic alone	May include laboratory, microbiological, and imaging investigations according to suspicion of deep infection or bone involvement
Therapeutic approach	Optimize local care and correct factors impairing healing; use antimicrobial agents when appropriately indicated	Timely assessment of infection severity and extent; systemic antimicrobial therapy and surgery when indicated
Main limitation	Individual signs are not specific to infection and do not demonstrate invasive involvement	Signs do not independently confirm deep infection, osteomyelitis, or sepsis

Sources: Sibbald et al. [1], Woo and Sibbald [2], IWII [3], and IWGDF/IDSA [4].

and the possibility of deep or spreading infection [2,3,7].

Evidence from Systematic Reviews and Expert Consensus Statements (2025–2026)

The 2026 systematic review by González-Suárez et al. evaluated the diagnostic accuracy of clinical signs associated with infection and biofilm in chronic wounds. Of 2,064 publications initially identified, only four studies met the inclusion criteria. None was specifically designed to validate a clinical diagnosis of "biofilm," and substantial heterogeneity precluded a meta-analysis [5].

The authors found no validated noninvasive scale for detecting biofilm. This limitation is important when interpreting NERDS, STONEES, and related tools, because wound-bed deposits, malodor, and delayed healing may indicate the need for further assessment but do not independently demonstrate biofilm or establish a causal relationship between biofilm and the observed changes [5].

The 2025 Delphi study by Ivory et al. achieved expert consensus on 11 potential signs associated with biofilm in chronic wounds. These included a persistent surface layer, recurrence of pathological changes after cleansing, chronic low-grade inflammation, tunneling, and adverse changes in granulation tissue [6]. These findings reflect expert appraisal of potentially meaningful clinical observations, but they do not establish the diagnostic sensitivity or specificity of these signs.

Another adjunctive tool, the Therapeutic Index for Local Infections (TILI), was developed to support clinical judgment in local wound infections. Its use must likewise take account of the patient's overall condition, the severity of local changes, wound etiology, and individual risk [3,8].

In summary, the available evidence supports the use of clinical mnemonics and adjunctive tools for structured recognition and documentation of adverse changes in chronic wounds. However, they do not replace clinical judgment or independently confirm infection or biofilm. Further studies are needed to validate these tools against clinically meaningful outcomes, the extent of tissue involvement, and prognosis [3,5,6].

Clinical Assessment and Diagnostic Approach in Suspected Chronic Wound Infection

Contemporary diagnostic assessment is based on the patient's clinical condition, wound etiology, local wound progression, and individual risk factors. The 2026 IWII continuum helps distinguish colonization, local infection with subtle signs, local infection with overt signs, spreading infection, and systemic infection. Laboratory investigations, microbiological testing, and imaging play complementary roles depending on the specific clinical question [3].

Clinical Assessment

The first step is to obtain a detailed medical history and perform a clinical examination of the wound and the patient. The history should clarify wound duration, changes in pain, changes in the amount and nature of exudate, wound enlargement, treatments undertaken to date, and comorbid conditions.

Wound examination includes assessment of size and depth, wound-bed condition, necrotic tissue, the amount and nature of exudate, malodor, local temperature, and erythema and edema of surrounding tissues. Particular attention should be paid to new or worsening pain and changes in the surrounding skin that may suggest developing infection.

Assessment should also cover the patient's general condition, body temperature, and signs of systemic infection. Risk factors such as diabetes mellitus, peripheral arterial disease, and immunosuppression should be identified, as they can affect healing and increase the risk of complications [3,7].

Standardized measurements and similar lighting conditions should be used for serial examination and photographic documentation. In darker skin tones, classic bright-red erythema may not be obvious; local inflammation may instead present with purplish, brownish, or grayish discoloration, warmth, induration, and other changes [3].

Identifying the underlying cause of the chronic wound is a key component of diagnosis. In venous ulcers, venous hypertension and peripheral edema should be assessed; in arterial ulcers, peripheral circulation and tissue perfusion; and in diabetic ulcers, neuropathy, impaired blood supply, and mechanical loading. These factors must inform the interpretation of clinical findings and subsequent treatment decisions [3,7].

When chronic wound infection is suspected, laboratory investigations should be selected purposefully. A complete blood count, CRP, and ESR may aid assessment when deep infection is suspected, although normal values do not exclude localized involvement. In diabetic ulcers with equivocal clinical findings, the International Working Group on the Diabetic Foot/Infectious Diseases Society of America (IWGDF/IDSA) recommends considering CRP, ESR, or procalcitonin; a laboratory result alone does not establish a diagnosis [3,4].

Laboratory testing is ordered according to the clinical presentation and degree of suspicion of infection. A complete blood count, C-reactive protein (CRP), and other inflammatory markers may support assessment of suspected more serious infection. However, these results should not be interpreted in isolation, because normal values do not exclude localized infection and elevated markers may also reflect other inflammatory processes [3].

If systemic infection or sepsis is suspected, lactate, renal function, and other measures of organ dysfunction are assessed as clinically indicated [9-11]. The results are interpreted together with clinical findings to determine disease severity and the need for additional diagnostic and therapeutic measures.

Microbiological Testing

Microbiological testing can inform the selection of antimicrobial treatment, but results must be interpreted within the clinical context. A positive culture from a wound specimen is not synonymous with clinical infection, since chronic wounds are often colonized by microorganisms without necessarily having an infectious process that requires antibiotic treatment.

For adults with leg ulcers, the National Institute for Health and Care Excellence (NICE NG152) does not recommend routine microbiological sampling at the initial assessment, even when infection is suspected. Reassessment is recommended if the condition deteriorates rapidly or has not begun to improve within 2–3 days after starting antibiotics; at that point, sampling after wound cleansing may be considered [7]. This algorithm should not automatically be extrapolated to diabetic foot infection.

Specimen selection is crucial in microbiological diagnosis. The 2026 IWII consensus recommends a tissue sample when clinically feasible; if a wound swab is necessary, the Levine technique should be used after cleansing rather than superficial swabbing of exudate [3]. For diabetic foot infection, IWGDF/IDSA recommends aseptically obtained tissue through curettage or biopsy; when osteomyelitis is suspected, bone culture is more informative than a soft-tissue sample [4].

With the Levine technique, a specimen is obtained from a cleansed, viable wound bed by pressing and rotating the swab over a small area to express tissue fluid. Sampling solely from necrosis, slough, retained discharge, or intact surrounding skin is not recommended. Samples should be collected by trained professionals when clinically indicated [3].

The decision to prescribe antibiotics should be based on clinical signs and symptoms of infection, not solely on bacteria being present in the wound or on a positive microbiological result [7].

Imaging

Imaging is not necessary for every chronic wound but is important when a deep abscess, bone involvement, or other complications are suspected. The choice of modality depends on clinical findings and the specific diagnostic concern.

Plain radiography is often the initial imaging investigation when osteomyelitis is suspected, although early bone changes may not be visible. In diabetic ulcers, IWGDF/IDSA suggests an initial combined assessment using a probe-to-bone test, plain radiographs, and ESR and/or CRP/procalcitonin; magnetic resonance imaging (MRI) is performed when diagnostic uncertainty remains. Other imaging modalities may be considered when appropriate [4]. A positive probe-to-bone test should not be used alone to confirm osteomyelitis.

Summary of the Diagnostic Approach

Clinical assessment and diagnosis of chronic wound infection require integration of the history, local findings, the patient's overall condition, and individual risk factors. Laboratory, microbiological, and imaging investigations are selected according to clinical indications and do not replace clinical judgment. Distinguishing colonization from clinical infection is particularly important because it determines the need for further investigation and antimicrobial treatment [3,7].

Practical Clinical Decision Algorithm

For every chronic wound, the underlying reason for nonhealing, vascular status, local wound progression, and the patient's general condition should be established first. The mnemonics support this process but do not automatically determine the need for microbiological testing, antibiotics, or surgery. When signs of severe infection are present, action must be immediate regardless of the number of NERDS/STONEES signs [3,4,7].

Assessment and treatment should be documented and reviewed according to the clinical course. For adults receiving treatment for an infected leg ulcer, NICE recommends reassessment if improvement has not begun within 2–3 days or if significant deterioration occurs at any time [7].

Differential Diagnosis in Suspected Chronic Wound Infection

Differential diagnosis is essential in chronic wound assessment because certain local and systemic conditions can mimic signs of infection. Erythema, edema, pain, exudate, or delayed healing alone is insufficient to confirm an infectious process. NERDS and STONEES findings must therefore be interpreted within the overall clinical picture.

Table 2: Suggested Management by Clinical Situation (Not an Independent Diagnostic Scale).

Clinical situation	Primary assessment	Next step
Nonhealing wound without convincing infection	Etiology, perfusion, pressure, edema, nutritional status, local care	Optimize treatment directed at the underlying cause; no routine systemic antibiotics
Subtle local changes (NERDS)	Monitor progression; assess the wound bed and reasons for stalled healing	Cleansing, debridement/dressings, and a topical antiseptic as indicated; reassess
Overt local signs, increasing erythema or pain (STONEES)	Clinical diagnosis; assess severity and peripheral perfusion	Consider microbiology, systemic antibiotics, or surgical assessment according to infection type and severity
Suspected abscess, bone involvement, or osteomyelitis	Probe-to-bone test in a suitable ulcer; imaging and laboratory investigations	Specialist assessment; appropriate tissue/bone sampling and source control
Systemic deterioration, necrosis, disproportionate pain, hemodynamic changes	Assess for sepsis and necrotizing infection	Emergency referral; do not wait for a mnemonic threshold or culture results

Sources: IWII [3], IWGDF/IDSA [4], NICE NG152 [7], and Surviving Sepsis Campaign [10].

The main conditions to distinguish from chronic wound infection include:

- Microbial colonization: the presence of microorganisms in a wound without convincing clinical evidence of infection requiring antimicrobial treatment. A positive microbiological culture alone does not confirm clinical infection.
- Healing-related inflammation: local erythema, edema, and tenderness may be part of the normal inflammatory response or may develop after mechanical cleansing and debridement.
- Contact dermatitis: a reaction to dressings, adhesives, topical antiseptics, or other wound-care products that may cause erythema, itching, rash, and sometimes exudation.
- Venous stasis and stasis dermatitis: these may cause edema, erythema, and changes in the skin surrounding an ulcer that can resemble infection.
- Arterial ischemia: this may cause severe pain, necrosis, and delayed healing. Peripheral circulation must be assessed, particularly before compression therapy or debridement.
- Other inflammatory and dermatological conditions: for example, pyoderma gangrenosum and vasculitis, which may cause painful ulcers and tissue damage and require specific diagnostic approaches.

Differentiating these conditions relies on the history, clinical examination, wound progression, and targeted additional investigations. A specialist consultation and, in selected cases, biopsy may be necessary for atypical, progressive, or nonhealing lesions. When infection is suspected, diagnostic assessment should not be delayed, especially in the presence of rapidly progressing tissue damage or systemic signs of infection [9-11].

Thus, NERDS and STONEES should be used as adjunctive clinical tools rather than independent diagnostic criteria. Their interpretation must be accompanied by assessment of alternative explanations for the observed signs and evaluation of disease severity.

Therapeutic Principles

Treatment of chronic wounds with clinical signs of infection requires a comprehensive, individualized approach aimed at controlling the infectious process, creating conditions conducive to healing, and addressing the underlying wound cause. Therapeutic strategy is determined by clinical assessment, infection severity, wound-bed condition, vascular impairment, and comorbidities. The main components are local wound care, prudent antimicrobial use, surgery when necessary, and multidisciplinary follow-up [3,7].

Local Treatment

Local treatment is a core component of chronic wound care and includes wound cleansing, exudate management, appropriate dressing selection, and removal of nonviable tissue when clinically indicated. Dressing selection should take into account exudate volume, wound-bed condition, sensitivity of the surrounding skin, and the need to maintain a suitable moist environment for healing. Where deposits, necrotic tissue, or suspected biofilm are present, cleansing and debridement may be considered. Biofilm is an organized community of microorganisms attached to the wound surface and surrounded by a protective matrix that can hinder control of the microbial population. However, it is difficult to identify clinically, so neither deposits nor a nonhealing wound proves the presence of biofilm. Debridement may facilitate the removal of nonviable tissue and contaminants, but the method must be individualized according to perfusion, pain, bleeding risk, wound location, and comorbidities [3].

In significant arterial ischemia, aggressive debridement may worsen tissue injury. In the presence of dry, stable necrosis and impaired perfusion, the sequence of debridement, vascular assessment, and possible revascularization is determined individually by a qualified team. Vascular and surgical assessment should not be delayed when infection is associated with severe ischemia [3,4,12].

Topical antiseptics and antimicrobial dressings have a role in suspected or established local infection after individual assessment, but they are not universally necessary for every chronic wound. IWII 2026 recommends selection based on antimicrobial spectrum, cytotoxicity, pH, allergenicity, local treatment goals, and available resources [3]. Antiseptics, antimicrobial dressings, and topical antibiotics must be distinguished; in diabetic foot infection, topical antibiotics do not replace standard antibiotic and surgical care [4].

For venous ulcers, NICE highlights the limited evidence for certain topical antiseptic and antimicrobial treatments. Accordingly, these agents should not replace fundamental wound care measures or treatment of the underlying cause of nonhealing. Compression therapy may be an essential component of venous ulcer treatment, but arterial perfusion must be assessed first to determine whether compression is appropriate for the individual patient [7].

When biofilm is suspected, standard management remains multifaceted: addressing the wound cause, cleansing, appropriate debridement, exudate control, and targeted topical antimicrobial treatment when indicated. It should not be assumed that a particular “antibiofilm” product has been clinically proven superior across all wound etiologies; the quality of supporting evidence varies [3,5,6].

Systemic Antibiotic Therapy

Systemic antibiotics are not a means of accelerating the healing of a colonized but clinically uninfected wound. They are indicated for clinical infection when systemic treatment is required, particularly where infection spreads beyond the wound bed, involves deeper tissues, or produces systemic manifestations. For overt local infection without spreading, the need for systemic therapy is determined individually and should not be inferred mechanically from NERDS or STONEES [3,4,7].

For venous leg ulcers, NICE recommends antibiotic treatment in the presence of clinical signs of infection, such as erythema or swelling spreading beyond the ulcer, local warmth, increasing pain, or fever [7]. Clinical judgment should also account for the rate of symptom progression, the patient's overall condition, and

the risk of complications.

Antibiotic selection depends on infection severity, likely pathogens, available microbiological results, previous antibiotic exposure, drug allergies, renal and hepatic function, and other comorbidities. Oral administration is generally preferred for patients who can take oral medication and have no indication for intravenous treatment. Severe infection, systemic deterioration, or suspected deep tissue involvement may require hospitalization and intravenous antibiotics [7,10,11].

The duration of antibiotic therapy depends on the type, depth, and severity of infection and the clinical response. For diabetic foot infection involving only skin and soft tissue, IWGDF/IDSA generally recommends a 1–2-week course, with individual exceptions [4]. If treatment fails, reassessment should address inadequately drained infection, ischemia, osteomyelitis, an inappropriate antibiotic, or incorrect identification of the wound etiology. The antimicrobial spectrum should be narrowed when possible after microbiological results become available [3,4,7].

In the absence of clinical signs of infection, antibiotics should not be used solely to promote chronic wound healing. Judicious antibiotic use is important both for patient safety and to limit the development of antimicrobial resistance [3,7].

In a systemically stable patient with infection, treatment should follow recommendations specific to the wound type. For example, regimens and treatment durations for diabetic foot infection are not identical to those for an infected venous ulcer. Selection takes into account likely pathogens, local resistance patterns, renal function, allergies, previous antibiotic therapy, and the feasibility of infectious source control [4,7].

Surgical Treatment

Surgical assessment is necessary when an abscess, extensive necrosis, deep infection, rapidly progressive tissue damage, or a need for infectious source control is suspected. Depending on the clinical circumstances, surgical debridement, incision and drainage of an abscess, or other interventions to remove infected and nonviable tissue may be required.

A deep abscess, gangrene, necrotizing infection, or severe diabetic foot infection warrants urgent specialist evaluation and consideration of surgical source control. For diabetic foot infection, IWGDF/IDSA recommends early surgical consultation in severe infection and certain complicated moderate infections; vascular assessment is also often needed [4,12]. Suspected osteomyelitis requires targeted diagnostic evaluation but does not necessarily imply an immediate need for amputation.

Debridement must be tailored to local blood supply, anatomical location, depth of injury, and the patient's overall condition. In substantial ischemia, restoration of perfusion may need to be planned first or concurrently. In diabetic ulcers, interventions should be undertaken by appropriately qualified healthcare professionals in accordance with the individual treatment plan [11].

Amputation is not a routine consequence of positive clinical infection criteria, including STONEES criteria used as an adjunct to wound infection assessment. It is considered in specific severe clinical circumstances, such as irreversible tissue damage, uncontrolled infection, or a limb whose viability cannot be preserved using other appropriate methods. The decision requires individualized assessment and, whenever possible, multidisciplinary discussion.

Multidisciplinary Approach and Treatment of the Underlying Cause

Effective chronic wound management often requires collaboration among wound-care specialists, vascular surgeons, general surgeons, infectious disease specialists, endocrinologists, dermatologists, nurses, and other professionals according to wound etiology and patient condition. A multidisciplinary approach is especially important in diabetic ulcers, peripheral arterial disease, deep infections, and wounds that fail to improve as expected.

Treating the underlying cause is essential for sustained control of a chronic wound. In venous ulcers, appropriate compression should be considered after arterial assessment; in peripheral arterial disease, vascular investigations and possible revascularization should be evaluated [7,12]. In neuropathic plantar diabetic ulcers, effective offloading is fundamental. For certain uncomplicated ulcers, IWGDF prioritizes a nonremovable knee-high device, while contraindications and infectious complications require individualized management [13].

Additional attention should be paid to nutritional status, protein and energy intake, nutritional deficiencies, pain control, and patient education regarding proper wound care. These measures help create conditions conducive to healing but must be individualized and must not replace treatment of established vascular disorders or infectious complications.

Follow-up should include regular assessment of wound size and depth, wound-bed condition, exudate, pain, surrounding tissues, and the patient's overall condition. If improvement is not as expected, deterioration is rapid, or systemic signs of infection appear, the treatment plan should be promptly reassessed, with referral for specialist or hospital care when needed [3,7,9,10].

In diabetic ulcers, peripheral vascular assessment may require Doppler signals and measurements of the ankle-brachial index (ABI) and/or toe-based indices, because no single measurement reliably excludes peripheral arterial disease [12]. In neuropathic plantar ulcers, inadequate offloading may be the main cause of stalled healing despite optimal local care [13].

Summary of Therapeutic Principles

Treatment of infected chronic wounds should be based on clinical assessment and combine appropriate local wound care, judicious use of systemic antibiotics, surgery when required, and management

of the underlying wound cause. Distinguishing colonization from clinical infection, tailoring treatment individually, and regularly reassessing the response are essential. Severe infection, suspected deep tissue involvement, or systemic deterioration requires timely specialist referral [3,7,9,11].

Distinguishing Local Infection from Infectious Emergencies

Distinguishing localized chronic wound infection from severe infectious complications is an essential component of clinical assessment and management decisions. NERDS and STONEES can help identify signs suggestive of a local infectious process, but they are not diagnostic tools for sepsis and should not be used alone to determine the severity of systemic infection [3].

Sepsis is life-threatening organ dysfunction caused by a dysregulated host response to infection [9]. The updated 2026 Surviving Sepsis Campaign international guidelines emphasize early recognition, timely management of the infectious source, hemodynamic assessment, and appropriate use of antimicrobial agents [10]. NERDS and STONEES do not diagnose sepsis and do not replace assessment of vital signs and organ function.

Emergency medical assessment is required for rapidly spreading erythema or edema, severe pain or pain disproportionate to the visible local findings, rapidly progressing necrosis, marked systemic malaise, confusion, hemodynamic instability, or other findings suggestive of severe infection. Suspected necrotizing infection, deep abscess, or osteomyelitis requires prompt specialist investigation and treatment [3,7-11].

When sepsis or necrotizing infection is clinically suspected, immediate referral to emergency care, assessment of organ function, early appropriate antibiotic therapy, and source control are priorities. Neither a negative culture nor a low mnemonic sign count justifies delaying critically needed intervention [3,4,10].

Clinical deterioration must not be underestimated, even when the number of NERDS or STONEES signs is below a specified threshold. When a severe infectious complication is suspected, emergency assessment and treatment decisions must be based on the overall clinical picture rather than a mechanical count of individual signs.

Terminological Note: Another Medical Meaning of NERDS

In the medical literature, NERDS also denotes a rare eosinophilic syndrome described by Butterfield, Leiferman, and Gleich in 1993. The name derives from the English expression Nodules, Eosinophilia, Rheumatism, Dermatitis and Swelling [14].

This syndrome is distinct from the NERDS mnemonic used in wound care to aid recognition of signs suggestive of local infection in chronic wounds. Because the acronyms coincide, their meanings must be distinguished according to medical context to avoid terminological confusion.

Conclusion

NERDS and STONEES can support structured clinical monitoring of chronic wounds but are not stand-alone infection tests. NERDS groups signs of delayed healing and wound-bed changes, whereas STONEES groups signs that increase suspicion of local deterioration, deeper involvement, or spreading infection. Interpretation should incorporate the contemporary IWII continuum, wound progression, wound etiology, and patient risk [1-3,5].

Despite their potential clinical utility, both mnemonics have limitations and must not be regarded as independent diagnostic criteria. A specified number of signs does not, by itself, confirm infection and is not sufficient justification for prescribing systemic antibiotics, ordering microbiological or imaging investigations, or undertaking surgical treatment. These decisions must be based on comprehensive clinical assessment, wound etiology, individual risk factors, the patient's overall condition, and appropriate additional investigations [1-3,7].

Optimal treatment requires timely recognition of clinical infection, distinguishing it from microbial colonization and noninfectious conditions that may mimic infection, and targeted treatment of the underlying cause of nonhealing. Judicious antimicrobial use, appropriate local care, timely specialist referral, and multidisciplinary follow-up are essential to limit complications and establish conditions for successful healing.

Thus, NERDS and STONEES should serve as adjunctive mnemonics within a comprehensive system of diagnosis and management. Further high-quality studies are needed to validate them against clinically meaningful endpoints and to develop reliable noninvasive methods for biofilm detection [3,5,6].

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