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Retrospective case series: Implementation of the Wound Hygiene protocol for wound healing

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Introduction

Wound Hygiene is a simple, effective concept designed as a protocol of care to support the healing of hard-to-heal wounds. It focuses on cleaning and decontaminating the wound while addressing barriers to healing, particularly biofilm. The protocol consists of four simple steps: Cleanse, Debride, Refashion, and Dress **[Figure 1; Table 1]**.

Wound Hygiene should be initiated at the first referral, following a comprehensive holistic assessment to identify wound aetiology and any comorbidities. Much like everyday hygiene practices such as washing hands, brushing teeth and showering, the key to Wound Hygiene lies in repetition. It must be continued at every dressing change until full healing occurs (Murphy et al, 2022).

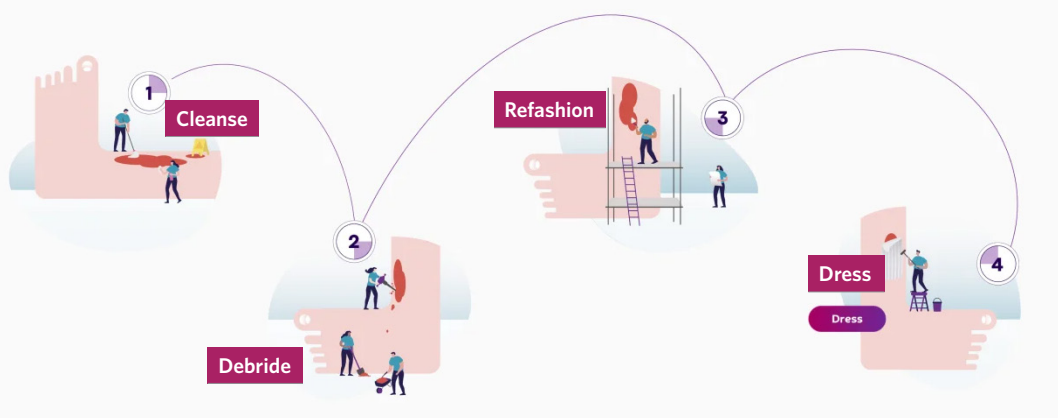

Figure 1. Four key steps of the Wound Hygiene protocol: Cleanse, Debride, Refashion and Dress

The rationale behind Wound Hygiene: Biofilm formation and development

While the exact role of biofilm in non-healing wounds is still under investigation, it is becoming widely accepted that biofilm is present in most hard-to-heal wounds **[Box 1]**. Studies (Bjarnsholt et al, 2017; Malone et al, 2017) estimate that 60–100% of hard-to-heal wounds contain biofilm, with the actual prevalence likely approaching 100%. This suggests that all non-healing wounds may have biofilm on at some part of the wound bed (Bjarnsholt et al, 2017; Malone et al, 2017). Therefore, clinicians should approach all hard-to-heal wounds with the assumption that biofilm is present and manage them accordingly until full healing is achieved. This includes carrying out Wound Hygiene on every wound throughout its healing process.

Biofilm impacts wound healing by creating an environment where microorganisms (e.g. fungi, bacteria, yeasts and viruses) can multiply and evade immune responses (Karlsson et al, 2012; Hirschfeld, 2014). It prolongs the inflammatory state, induces chronic inflammation and impairs skin barrier function by disrupting skin permeability (Roy et al, 2014), while also preventing normal cellular migration. Additionally, biofilm protects microorganisms from antibiotics, antiseptics and host immunity, making biofilm management essential in the care of non-healing wounds (Bowler and Parsons, 2016; Siaw-Sakyi, 2018; Mori et al, 2019). The Wound Hygiene framework offers a structured, proactive approach to biofilm management within a holistic wound care protocol. By incorporating cleansing, debridement, refashioning of wound edges and appropriate dressing selection, this strategy helps prevent further wound deterioration and promotes healing.

What are biofilms?

Biofilms are defined as aggregates of microorganisms that attach to biotic (living surfaces, such as biological tissues), abiotic surfaces (non-living surfaces, such as wound dressings), or even each other. These microorganisms are encased in a self-produced extracellular matrix, known as extracellular polymeric substance, which makes them resistant to antimicrobial agents, including antibiotics and antimicrobials (World Union of Wound Healing Societies, 2016; Yin et al, 2019). Biofilms are often polymicrobial, consisting of clusters of various types of bacterial cells that grow at different rates, making them difficult to treat (Fletcher et al, 2020).

Table 1. Best practices for the Wound Hygiene protocol

Protocol	Definition	Rationale	Tools	Tips in practice
1  Cleanse wound and surrounding skin	Active removal of surface contaminants, loose debris, slough, softened necrosis, microbes and/or remnants of previous dressings from the wound bed and surrounding skin (Haesler et al, 2022)	• Prepares the wound for debridement by removing loose necrotic tissue and further sources of contamination • Reduces burden of wound-colonising microorganisms • Delays formation of biofilm • Improves visualisation of the wound bed and edges • Enhances patient comfort and helps them feel socially clean	• Cleansing solution: Non-cytotoxic, antiseptic wound cleanser (wash/surfactant) • Gauze or non-woven pad: For gentle cleansing • Pads or wipes: For quick and easy cleansing • Forceps: For precise handling of dressings and debris • Water or saline: To rinse and flush the wound, in accordance with local guidelines	• Prevent cross-contamination by ensuring that pads or wipes are not reused, either by the healthcare professional or between different areas of the wound • Allow cleansing solutions sufficient dwell time or soaking to effectively solubilise debris and aid in biofilm removal
2  Debride wound bed	The physical removal of biofilm, devitalised tissue (e.g. necrosis, slough, eschar), debris, exudate, hyperkeratosis, remains of previous dressings, organic matter, and any other barriers to healing	• Breaks up and disrupts biofilm formation • Removes devitalised tissue and other barriers to healing	• Mechanical: Soft debridement pad or sterile gauze • Sharp: Curette, scalpel, forceps, tweezers • Surgical: Typically performed in an acute setting • Larval (biological debridement): Use of larvae to consume devitalised tissue • Other: Hydrosurgery, ultrasonic	• Ensure all instruments or devices used for debridement are sterile to avoid introducing additional contamination • After debridement, rinse the wound and periwound skin with a liquid surfactant or antimicrobial solution (Murphy et al, 2020) • Debridement should be performed regularly and repeated as necessary to maintain wound progression (Wilcox et al, 2013)
3  Refashion wound edges	Agitating and opening of wound edges to the extent that pinpoint bleeding occurs	• Remove devitalised tissue, callus, hyperkeratotic debris senescent cells at wound edges that may be harbouring biofilm • Removal is necessary to facilitate epithelialisation, wound contraction and stimulate expression of growth factors, to kick start the formation of healthy skin (Murphy et al, 2020; 2022)		• Pay particular attention to surfaces in contact with the wound bed, such as areas with slight undermining or loosely attached epithelial tissue, as these are especially likely to harbour biofilm • If in doubt about mechanically debriding wound edges to pinpoint bleeding, consult a more specialist practitioner, provided that local practice, patient tolerance and consent permit it
4  Dress wound	Apply a dressing to address any residual biofilm and prevent contamination and recolonisation and, therefore biofilm reformation	Biofilm can reform rapidly, and repeated debridement alone is unlikely to prevent its regrowth	Appropriate antimicrobial dressing that can also absorb and manage exudate (e.g. Aquacel® Ag+ Extra™)	

Dressing selection

The first three stages of the Wound Hygiene protocol remove barriers to wound healing, allowing an antimicrobial dressing to achieve maximum efficacy (Percival et al, 2019). Some wound dressings can support wound hygiene by disrupting biofilm, killing organisms within it and preventing reformation through different modes of action.

It is important to be able to differentiate between antimicrobials and antibiofilm agents. When choosing an antimicrobial dressing, its antibiofilm properties should be considered, along with requirements, such as exudate management capabilities. Following the initial three steps of the Wound Hygiene protocol, the fourth step calls for the use of a dressing that manages any residual biofilm and prevents reformation. To maximise this, antimicrobial dressings can be used, when indicated following a holistic assessment (Murphy et al, 2020).

Aquacel Ag+ Extra is technologically designed to manage biofilm within the dressing and is indicated for moderate to highly exuding,

Box 2. What is MORE THAN SILVER™ Technology?

The MORE THAN SILVER™ Technology in Aquacel Ag+ Extra formulation includes:

- **Benzethonium chloride (BEC)**: A surfactant that reduces surface tension, helping to dissolve and remove contaminants and necrotic tissue
- **Ethylenediaminetetraacetic acid (EDTA)**: A metal-chelating agent that weakens biofilm structure and amplifies the antibacterial activity of silver ions, significantly improving their effectiveness against microorganisms
- **Ionic silver**: A broad-spectrum antimicrobial that accumulates at microbial cell membranes, disrupting multiple cellular processes. It loosens, disrupts and lifts biofilm to expose microorganisms. The silver kills infection-causing bacteria, including methicillin-resistant *Staphylococcus aureus*, *vancomycin-resistant enterococci* and *extended-spectrum beta-lactamase*-producing bacteria (Parsons, 2014, Parsons et al, 2016, Bowler and Parsons, 2016).

Box 3. What is Hydrofiber® Technology?

Hydrofiber® Technology in Aquacel Ag+ Extra is a patented technology in which fibres of high-quality cellulose are carboxymethylated, altering their structure to allow better absorbency and retention of fluid. It is a soft, absorbent material that transforms into a gel on contact with wound fluid. These fibres are then processed to mesh them together to form a stable fleece layer. When exposed to fluid, the fibres swell to form a clear, soft, cohesive gel structure that closely conforms to the wound bed. As the fibres swell, the fluid and its contents (e.g. bacteria, dissolved contaminants and necrotic tissue) are trapped and held within the dressing (Walker et al, 2003; McQueen, 2010; Walker and Parsons, 2010). This mechanism supports effective wound cleansing with each dressing change. In addition, the gelling action prevents lateral spread of fluid through the dressing to protect the periwound skin, reduce risk of maceration, and help to minimise wound and cross-infection during removal (Bowler et al, 1999; Walker et al, 2003) and promote a moist wound healing environment (Wounds International, 2017).

hard-to-heal and acute wounds with infection or a high risk of infection. The dressing design uses two unique technologies in synergy to manage biofilm: MORE THAN SILVER™ Technology **[Box 2]** and Hydrofiber™ Technology **[Box 3]**.

Conclusion

This retrospective case study series highlights successful application of the Wound Hygiene protocol in treating hard-to-heal, chronic wounds by healthcare practitioners across the Asia-Pacific region. Cases include complex wounds such as bilateral lower-limb ulceration associated with verrucous non-haemorrhagic elephantiasis (Case 5, pages 14–15) and necrotising fasciitis (Case 6, pages 16–17; Case 7, pages 18–19).

Many of the wounds discussed were infected, and some patients faced a high risk of amputation at the time of presentation. The consistent application of the Wound Hygiene protocol: Cleanse, Debride, Refashion and Dress using Aquacel Ag+ Extra demonstrated significant wound healing progress, with some cases achieving full closure.

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CASE 1: Infected diabetic foot ulcer with exposed tendon

Authors: **Prof Dato Dr Harikrishna K Ragavan Nair**; Director of Hospital Kuala Lumpur; Head of Wound Care Unit, Hospital Kuala Lumpur, Malaysia; President of World Union of Wound Healing Societies; **Dr Prishela Banu a/p Kanavathi**, Medical Officer, Wound Care Unit; **Muhammad Zulfadhli bin Md Roslan**, Medical Assistant, Wound Care Unit

Patient presentation and history

A 64-year-old female with a medical history of type 2 diabetes mellitus, hypertension, hypercholesterolemia and poorly controlled glycaemic levels, presented with a non-healing diabetic foot ulcer on her left foot, which had been present for five months. Despite receiving dressing changes at a GP clinic, no improvement was observed. The ulcer was impairing the patient's ability to carry out normal activities and affecting her lifestyle and sleep quality. She also required substantial support from family members and friends to manage the emotional and physical challenges associated with the ulcer [Figure 2].

Wound assessment

The wound was assessed using T.I.M.E [Table 2]. The left foot ulcer, located on the plantar aspect of the hindfoot, measured 7cm (length) x 4cm (width) x 1cm (depth).

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 3]. Intended treatment outcomes were to: remove and inhibit infection, promote granulation and epithelial tissue development and facilitate wound healing.

The patient was advised to maintain foot hygiene by cleaning and drying the feet thoroughly, particularly between the toes; wearing well-fitting footwear; performing regular self-examinations of the feet to identify early signs of redness, blisters or signs of skin breakdown; and avoiding going barefoot to reduce the risk of injury and infection.

Wound review

Week 8

By week 8 of implementing the Wound Hygiene protocol, the patient's foot ulcer had reduced in size, with a significant decrease in slough. Healthy granulation tissue was observed, and signs of infection were no longer present. Wound edges showed early signs of contraction [Figure 3].

Week 21

By week 21, the ulcer had decreased further in size, with notable progress in wound edge contraction [Figure 4].

Table 2. Wound assessment using the T.I.M.E acronym

Tissue	50% granulation tissue, 40% slough and 10% epithelialisation. The tendon was exposed, but the wound did not extend into the bone
Infection	Signs of infection (slough, malodour)
Maceration/ Moisture	Moist wound bed, with moderate levels of clear exudate
Edges	Unhealthy wound edges, with evidence of undermining

Table 3. Wound Hygiene intervention

Cleanse 	The wound was cleansed with sterile water to remove debris and prepare the wound bed for further treatment.
Debride 	The wound was debrided using a surgical scalpel. Debridement was performed twice during the infection phase to remove thicker necrotic tissue and an amorphous gel-like substance.
Refashion 	Callus and hyperkeratotic debris at the wound edges were carefully removed using a scalpel to promote healthy tissue growth and improve wound healing.
Dress 	After vigorous cleansing, debridement and refashioning, Aquacel Ag+ Extra dressing was applied twice per week to maintain a moist wound environment and prevent the reformation of biofilm.

Discussion

After 30 weeks of following the Wound Hygiene protocol and using Aquacel Ag+ Extra dressing, 95% epithelialisation had occurred, and complete wound closure was achieved [Figure 5].

The clinician noted that the dressing effectively managed exudate through absorption, retention, and protection of the wound bed and periwound skin. The antimicrobial properties in the dressing reduced biofilm formation and provided an additional barrier against infection.

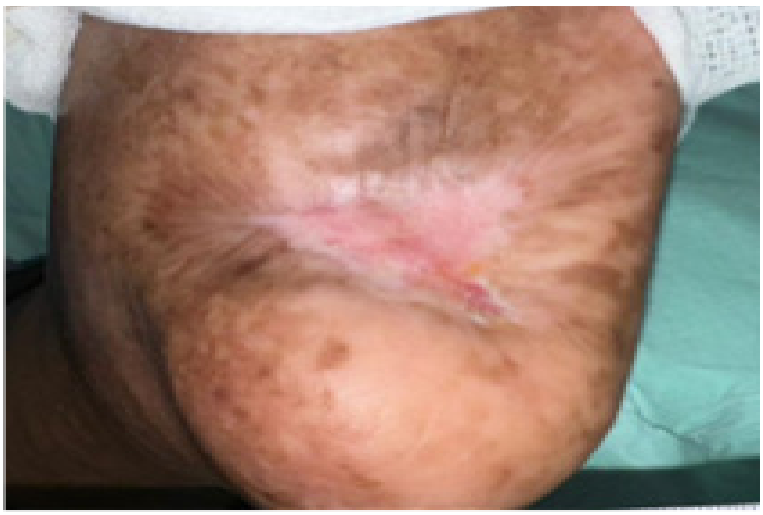
Case 1: Management of an infected diabetic foot ulcer with exposed tendon

Figure 2. Wound on presentation

Figure 3. Week 8 review of treatment with Aquacel Ag+ Extra

Figure 4. Week 21 review of treatment with Aquacel Ag+ Extra

Figure 5. Week 30 of treatment with Aquacel Ag+ Extra (end of treatment)



The patient also reported satisfaction with the dressing, particularly highlighting its comfort during application and wear, its ability to remain in situ in awkward-to-dress areas such as the heel, and pain-free removal.

CASE 2: Venous leg ulcer

Author: **Dr Hui-Hsiu Chang**, Attending Physician of Plastic Surgery, National Taiwan University Hospital; Yunlin Branch Unit, Plastic Surgery Wound Center, Yunlin, Taiwan

Patient presentation and history

A 71-year-old female presented with a two-month-old venous ulcer on her right calf [Figure 6]. The patient's medical and surgical history included controlled hypertension, hyperlipidaemia, type 2 diabetes, coronary heart disease, endometrial cancer, cardiac catheter stenting, left great saphenous vein dissection and varicocelectomy.

Wound assessment

The wound was assessed using T.I.M.E [Table 4]. The wound measured 2cm (length) x 1.5cm (width) x 0.5cm (depth) and presented with pigmentation, varicose veins, oedema and severe pain.

Following the initial assessment, the wound was dressed with a medical-grade honey-based dressing for seven weeks, but this approach showed limited improvement. By the fourth visit [Figure 7], wound deterioration was observed and due to this, a new wound care protocol needed to be implemented.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 5]. Intended treatment outcomes were to: promote granulation tissue development and facilitate wound healing.

In addition, empirical antibiotics (Zyvox) were introduced to address the underlying infection. To manage lower limb oedema, the patient was initially advised to wear elastic stockings. However, the patient found them uncomfortable and difficult to wear due to the tightness and her warm working conditions. As an alternative, she was instructed to use a resistance band, limit prolonged standing, adjust her diet and engage in regular exercise.

Wound review

Week 1

By week 1 of implementing the Wound Hygiene protocol, significant improvement was observed. The wound showed reduced discharge and increased granulation tissue [Figure 8]. Based on the wound culture report, which identified *E. coli* and *Proteus mirabilis*, the patient was switched to oral Cefixime for two weeks while continuing treatment with Aquacel Ag+ Extra as the primary dressing.

Table 4. Wound assessment using the T.I.M.E acronym

Tissue	50% slough and 50% necrotic tissue
Infection	Signs of infection (slough, pain, oedema)
Maceration/ Moisture	Moderate to high exudate (pale yellow, sticky), requiring 2-3 gauze dressing changes daily
Edges	1cm deep overhang at the superior edge (11–1 o'clock positions), no epithelialisation or cavity formation. Dry scabs with slight infiltration at the 12 o'clock position. Red periwound area

Table 5. Wound Hygiene intervention

Cleanse 	Due to the presence of necrotic tissue, slough and biofilm, the wound bed and surrounding skin were thoroughly cleansed with a surfactant cleansing foam solution. The wound was then mechanically cleansed with wet gauze and normal saline to remove loosely attached necrotic tissue, skin scales, crust and biofilm.
Debride 	Following cleansing, any remaining necrotic and unhealthy tissue was removed through sharp debridement (curved scissors, toothed forceps).
Refashion 	Wound edges were refashioned using scissors and wet gauze to remove dried exudate and hyperkeratosis.
Dress 	Aquacel Ag+ was applied as the primary dressing to control bacterial growth in the wound bed and reduce biofilm adhesion.

Week 4

By Week 4, epithelialisation was observed at the wound edges, marking further wound healing progress.

Week 9

By week 9 [Figure 9], the wound was significantly closing, with the wound bed filled with granulation tissue and only trace amounts of biofilm remaining.

Week 17:
Four months later, the wound was almost completely healed [Figure 10].

Discussion

With collaboration from multiple healthcare providers, continuous follow-up, and the implementation of the Wound Hygiene protocol, the wound showed significant improvement and was nearly healed after four months. The importance of lifestyle adjustments and long-term management of chronic conditions to ensure optimal health and quality of life was emphasised in this case.

Case 2: Management of a patient with a venous leg ulcer

Figure 6. Wound on presentation after initial treatment with a medical-grade honey-based dressing

Figure 7. Wound at start of treatment with Aquacel Ag+ Extra

Figure 8. Week 1 of treatment with Aquacel Ag+ Extra

Figure 9. Week 9 of treatment with Aquacel Ag+ Extra

Figure 10. Week 17 of treatment with Aquacel Ag+ Extra. Wound almost healed

CASE 3: Diabetic foot ulcers

Author: **Dr Jixue Liu**, Burn Surgeon, Xi'an Daxing Hospital, Xi An Shi, Shaanxi, China

Patient presentation and history

An 82-year-old female presented with three ulcers on her left foot which had been present for over a month [Figure 11]. The patient's medical history included type 2 diabetes, hypertension, bilateral hip replacement surgeries, severe hypoproteinaemia, malnutrition and poor glycaemic control. She also had lower extremity arterial occlusion, acral ischaemia and a local infection, with the wound reaching bone and leading to run-through osteomyelitis. On admission, the patient's foot was wrapped in gauze, with dull, swollen toes and grey, thickened nails. She was bedridden, unable to walk, and suffering from poor digestion, malnutrition, wound pain, anxiety and depression.

Wound assessment

The wound was assessed using T.I.M.E [Table 6]. The three ulcers on the lateral side of the foot, extending from the proximal metatarsophalangeal joint to the heel, measured 16cm (length) x 8cm (width), 2cm (length) x 2.5cm (width), and 1cm (length) x 1.5cm (width). The distal wound exhibited thick, yellowish-grey pus with malodour.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 7]. Intended treatment outcomes were to: remove and inhibit infection and biofilm reformation, promote granulation and epithelial tissue development and facilitate wound healing.

Wound review

Week 1

The largest of the three wounds was heavily infected and covered entirely in black necrotic tissue. It emitted a strong odour and exhibited significant exudate, redness and swelling. The extensive necrotic tissue and overhanging edges suggested a high likelihood of biofilm formation. Dressing changes were performed daily to manage the exudate.

Week 2

By week 2, the wound had progressed, with 75% yellow necrotic tissue and 25% granulation tissue. It showed moderate exudate, a slight odour, and continued redness and swelling [Figure 12]. At this point, dressing changes were reduced to every two days as improvements were observed.

Table 6. Wound assessment using the T.I.M.E acronym

Tissue	Sludge-like, infected necrotic tissue beneath the scab
Infection	Bacterial culture of the purulent exudate indicated proteus mirabilis. Biofilm suspected
Maceration/ Moisture	Thick, yellowish, purulent exudate
Edges	N/A

Table 7. Wound Hygiene intervention

Cleanse 	The wound bed was cleansed using pulse lavage, and the surrounding skin within a 20cm radius was treated with 0.5% povidone iodine and 0.9% sodium chloride to reduce bacteria.
Debride 	Fascia, necrotic skin, and fat pad were gradually removed with surgical scissors. Necrotic calcaneus and cuboid bones were excised using a rongeur. The wound was pulse-lavaged and rinsed with polyhexamethylene biguanide (PHMB). Sharp debridement was performed to remove infected necrotic tissue and black scabs.
Refashion 	Wound edges were refashioned with surgical scissors until healthy tissue was reached.
Dress 	For the first 25 days, the infected wound with necrotic tissue and biofilm was soaked with PHMB for 15 minutes. The wound was then covered with Aquacel Ag+ Extra, packed with Aquacel Ag+ Extra in any undermined areas around the wound, and a gauze cotton pad was used as a secondary dressing.

Week 3

By week 3, the condition of the wound bed had improved, now consisting of 25% yellow necrotic tissue and 75% granulation tissue. Exudate was light, and no odour was present, although some redness and swelling remained [Figure 13]. From day 25 to day 56, a combination of platelet-rich fibrin with a decellularised matrix was applied. The wound was then covered with a gauze cotton pad as a secondary dressing, with dressing changes scheduled three times per week.

Week 4

The wound reduced in size to 15cm (length) x 7cm (width), with 25% yellow necrotic tissue and 75% granulation tissue. It continued to exhibit light exudate; there was no odour. Granulation tissue covered part of the exposed bone, and epithelial tissue began to advance at the wound's edge [Figure 14].

Week 5–8

By week 5, the wound measured 14cm (length) x 5cm (width) and was entirely covered in granulation tissue with light exudate and no odour. Weekly follow-ups ensured close monitoring of the wound's progress, leading to near-complete wound closure by week 8 [Figure 15].

Discussion

The treatment protocol in this case involved gradual changes in dressing frequency. In the first week, dressings were applied daily, followed by every two days in week 2, and every three days in week 3. This adjustment allowed for effective infection control, with the wound becoming progressively smaller and shallower at each review.

By week 2, the wound showed signs of improvement: the wound was clear of necrotic tissue, and healthy granulation tissue was beginning to form. Exudate was well-managed throughout, and both the clinician and the patient observed that the dressing could be removed easily without residue, contributing to overall comfort of the treatment. Furthermore, wound odour was significantly reduced, and the patient's pain was alleviated, which helped to improve their quality of life. The dressing's ability to absorb and retain exudate played a key role in accelerating wound healing and reducing the patient's anxiety and depression.

Case 3: Management of a patient with diabetic foot ulcers

Figure 11. Wound on presentation

Figure 12. Week 2 of treatment with Aquacel Ag+ Extra

Figure 13. Week 3 of treatment with Aquacel Ag+ Extra

Figure 14. Week 4 of treatment with Aquacel Ag+ Extra

Figure 15. Week 8 of treatment with Aquacel Ag+ Extra (end of treatment)

CASE 4: Diabetic foot ulcer located on the heel

Author: **Dr Nizam Bin Ali Husien**, Medical Officer and Coordinator, Wound Care Unit, Sarawak General Hospital, Kuching, Sarawak, Malaysia

Patient presentation and history

A 52-year-old female with a medical history of hypertension and diabetes mellitus was admitted to a private hospital. She complained of left foot pain and swelling for one week prior to admission and was diagnosed with a left foot abscess. She underwent incision and drainage. During the two-month follow-up, wound size remained the same. The wound later became infected. She was admitted to a government hospital and diagnosed with an infected left heel ulcer [Figure 16].

Wound assessment

The wound was assessed using T.I.M.E [Table 8]. The post-debrided wound over the left heel, extending to the plantar aspect, measured 14cm (length) x 6cm (width) x 0.5cm (depth).

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 9]. Intended treatment outcomes were to: promote granulation and epithelial tissue development and facilitate wound healing.

Wound review

Week 1

Slough at the wound base was decreasing, with more granulation tissue visible [Figure 17]. There were very minimal clinical signs of biofilm formation. The amount of exudate had reduced, and granulation tissue was starting to form over the lateral and plantar aspects of the wound. The periwound skin condition appeared much improved and cleaner after cleansing with a superoxidised solution.

Week 2

More granulation tissue was observed covering the wound base, including the plantar aspect of the left foot.

Week 9

The wound size had contracted over the left heel with granulation tissue present [Figure 18]. The wound at the plantar aspect of the left foot had already epithelialised. The surrounding skin appeared much healthier.

Week 11

The wound bed appeared healthy, with a significant reduction in size and almost full epithelialisation [Figure 19].

Table 8. Wound assessment using the T.I.M.E acronym

Tissue	30% slough found at the centre and medial part of the wound. Bone and tendon are not exposed
Infection	Moderate clinical signs of biofilms present. No purulent discharge or blood clots observed
Maceration/ Moisture	Moderate amount of exudate present. Dry periwound skin, covered with dry keratotic skin
Edges	Necrotic tissues observed at medial edges

Table 9. Wound Hygiene intervention

Cleanse 	All peeling skin (desquamation skin) was removed and the wound bed was cleansed with superoxidase solution. Loose slough and biofilm present at the wound base were scrubbed and cleansed using a high-pressure application of superoxidised solution.
Debride 	Sharp debridement in the operating theatre under spinal anaesthesia was performed to remove the remaining slough and necrotic tissue.
Refashion 	Wound edges were trimmed and refashioned.
Dress 	After vigorous cleansing, debridement and refashioning, the wound immediately was covered with Aquacel Ag+ Extra dressing to reduce the reformation of biofilm and optimise wound healing.

Discussion

The patient's infected left heel ulcer showed significant improvement following the implementation of the Wound Hygiene protocol. This protocol began with a thorough cleansing of the wound and periwound area using a superoxidised solution, followed by sharp debridement performed in the operating theatre. At each review, wound edges were trimmed to optimise healing conditions and Aquacel Ag+ Extra dressing was applied to manage the wound environment and promote wound healing.

Case 4: Diabetic foot ulcer located on the heel

Figure 16. Wound on presentation (a) posterior-lateral and (b) posterior-medial view of wound

Figure 17. Week 1 review (a) posterior-lateral and (b) posterior-medial view of wound

Figure 18. Week 9 review

Figure 19. Week 11 review

CASE 5: Bilateral lower-limb ulceration with verrucous non-haemorrhagic elephantiasis

Author: **Dr Pao-Jen Kuo**, Deputy Director, Department of Plastic and Reconstructive Surgery, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung City, Taiwan

Patient presentation and history

A 61-year-old male presented with bilateral lower limb ulcers and severe verrucous non-haemorrhagic elephantiasis [Figure 20]. The patient's medical history included chronic lymphoedema, hepatitis B, severe cirrhosis, portal hypertension, and a history of intravenous drug use. The severity of his condition required daily wound dressing changes lasting 2–3 hours, which significantly impacted his ability to work and socialise.

Wound assessment

The wound was assessed using T.I.M.E [Table 10]. The wound extended to the fascia, but its exact depth could not be measured due to the presence of severe verrucous non-haemorrhagic elephantiasis.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 11]. Intended treatment outcomes were to: prevent biofilm reformation, stabilise the wound and promote wound healing.

In addition, antibiotics were administered to control infection, and elastic bandages were applied to both legs to manage lymphoedema. The compression therapy helped realign the wound with the surrounding skin, facilitating lower limb compression and promoting epithelialisation and contraction of the wound.

Discussion

Continuous Wound Hygiene, including cleansing and debridement, was implemented alongside antibiotics to manage infection.

After treatment with Aquacel Ag+ Extra, healthy granulation tissue developed in the wound bed, and new skin formed along the wound edges [Figure 21]. Over the course of approximately one month, the wound demonstrated significant secondary healing, resulting in a reduction in the wound area without the need for additional reconstructive surgery [Figure 22a and 22b].

Table 10. Wound assessment using the T.I.M.E acronym

Tissue	Slough tissue, verrucous, pebble-like papules and nodules
Infection	Signs of infection (slough, pain)
Maceration/ Moisture	High levels of exudate and whitening of the skin surrounding the wound
Edges	Verrucous, pebble-like papules and nodules

Table 11. Wound Hygiene intervention

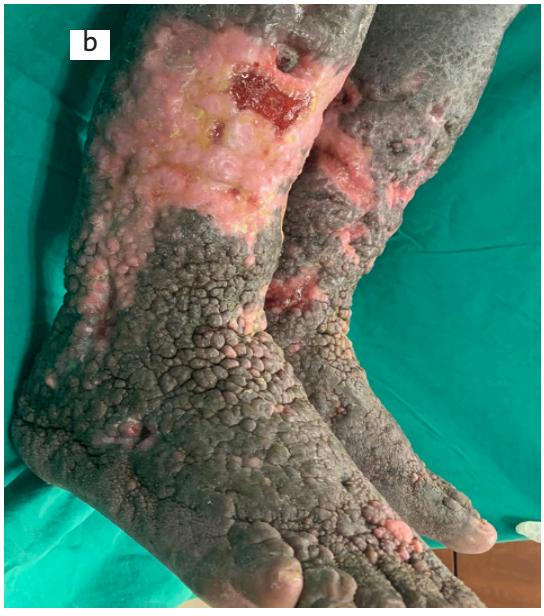
Cleanse 	Due to the presence of sloughy tissue, the wound bed and surrounding skin were thoroughly cleansed with a surfactant cleansing foam solution to remove scales and scabs, helping to reduce the risk of infection.
Debride 	Regular mechanical and surgical debridement was performed using a curette and surgical scrub brush in the operating theatre. This procedure was performed approximately once a week (total of four sessions were completed during the patient's hospitalisation stay). After each debridement session, the wound was irrigated with dilute povidone-iodine to prevent contamination.
Refashion 	Wound edges were refashioned using a curette to clean any undermined areas.
Dress 	Aquacel Ag+ Extra was applied as the primary dressing to reduce biofilm formation, prevent infection and absorb exudate.

Case 5: Bilateral lower-limb ulceration and severe verrucous non-haemorrhagic elephantiasis

Figure 20. Bilateral leg wounds on presentation, with multiple bacterial strains, a large amount of biofilm and unhealthy granulation tissue

Figure 21. Wound area progressively decreases, with epithelial tissue beginning to form along the wound edges

Figure 22. After approximately one month of treatment, the majority of the wound showed secondary healing, with a significant reduction in exudate and marked tissue regeneration. (a) frontal and (b) side view of the legs



CASE 6: Necrotising fasciitis of the right calf

Author: **Dr Li-Ren Chang**, Director, Burns Center, Changhua Christian Hospital, Changhua City, Changhua County, Taiwan

Patient presentation and history

A 51-year-old male presented with an untreated injury, which had persisted for three weeks, to the lateral side of his right calf. The patient's medical history included controlled diabetes and hypertension. A vascular assessment showed intact peripheral arterial circulation, with no evidence of occlusion and well-maintained blood flow.

Wound assessment

The wound was assessed using T.I.M.E [Table 12]. The patient presented to the emergency department with a fever, erythema and oedema at the injury site. Necrotising fasciitis was diagnosed, necessitating an urgent fasciotomy.

Following the fasciotomy [Figure 23], the wound was managed with saline-soaked gauze dressings, which were changed every eight hours. However, this regimen caused significant pain during dressing changes, which disrupted the patient's sleep, reduced his appetite and led to fluctuations in blood glucose levels. Due to these complications, a new wound care protocol needed to be implemented.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 13]. Intended treatment outcomes were to: reduce dressing frequency and pain, and improve sleep, appetite and wound healing.

Discussion

The primary challenge with this wound was managing excess exudate and preventing infection. Following debridement, Aquacel Ag+ Extra was chosen for its anti-biofilm properties.

Biofilm requires ongoing management, and to avoid additional debridement sessions, wound-cleansing dressings were introduced to moisturise the wound and assist with mechanical debridement. The treatment strategy involved alternating between Aquacel Ag+ Extra and wound-cleansing dressings. The former prevented biofilm regeneration, while the latter helped to remove thin layers of biofilm.

By refashioning the wound edges, where biofilm is most active, the entire wound environment was optimised for healing.

Table 12. Wound assessment using the T.I.M.E acronym

Tissue	Necrosis and unhealthy fascia
Infection	Signs of infection (pain, erythema, oedema)
Maceration/ Moisture	Moist wound bed with high levels of exudate
Edges	Red, swollen, and inflamed wound edges

Table 13. Wound Hygiene intervention

Cleanse 	Due to the presence of necrosis and unhealthy fascia, the wound bed and surrounding skin were thoroughly cleansed with tap water, hand soap, and saline to reduce bacterial colonies and disrupt biofilm.
Debride 	As necrotic tissue and biofilm were present, the wound bed was surgically debrided in the operating room.
Refashion 	Wound edges were refashioned to remove devitalised tissue that may harbour biofilm and delay healing.
Dress 	Following the first debridement session, a silver-containing gelling fibre dressing was applied to the wound bed [Figure 24]. However, when the dressing was removed, a white film, indicative of biofilm, was observed [Figure 25]. In response, at the second debridement session, the clinician transitioned to Aquacel Ag+ Extra as the primary dressing to absorb exudate and disrupt and destroy biofilm. A super-absorbent secondary dressing was also used to manage excess exudate and moisture around the wound edges [Figure 26]. As the deep fascia of the calf remained, a second fasciectomy was performed [Figure 27]. Following this procedure, the wound appeared much cleaner, and Aquacel Ag+ Extra was reapplied as the primary dressing, alongside a wound-cleansing dressing to assist in biofilm removal. Aquacel Ag+ Extra was changed every 2–3 days to promote granulation tissue formation [Figure 28 and 29]. As the wound improved, the patient's diet, pain and sleep also showed significant improvement.

After the wound showed signs of improvement, the patient was able to undergo skin graft surgery, which resulted in successful healing [Figure 30].

The Wound Hygiene protocol is key in managing such wounds, involving a continuous cycle of cleansing, debriding, refashioning and applying dressings. This process requires repeated evaluation of the wound and patient's overall condition, and addressing key questions such as: What stage of healing the wound in and what actions are needed?

Case 6: Necrotising fasciitis of the right calf

Figure 23. Post-fasciotomy wound containing residual necrotic tissue

Figure 24. Wound was treated with silver-gelling fibre dressings to absorb exudate and maintain moisture balance, with daily dressing changes

Figure 25. Despite treatment with a silver-gelling fibre dressing, the wound exhibits biofilm and necessitates additional surgical debridement under operating room conditions

Figure 26. After the dressing change, there was increased granulation tissue formation around the wound. However, the central fascia remains exposed and deep, necessitating further surgical intervention

Figure 27. Wound post-second fasciectomy, showing a cleaner wound bed

Figure 28. Application of Aquacel Ag+ Extra to assist in biofilm disruption

Figure 29. Wound in the proliferative stage, with visible granulation tissue formation

Figure 30. Post-skin graft, showing a smooth and healed wound site

CASE 7: Chronic limb-threatening ischaemia, presented with necrotising fasciitis

Author: **Dr Wuttichai Saengprakai**, Assistant Professor, Vascular Surgeon, Division of Vascular and Endovascular Surgery, Faculty of Medicine, Navamindradhiraj University, Bangkok, Thailand

Patient presentation and history

A 68-year-old male with a medical history of type 2 diabetes mellitus, hypertension, peripheral arterial disease and stage 3 chronic kidney disease presented to the emergency department and was diagnosed with necrotising fasciitis on the dorsum of his right foot. Initial surgical debridement was performed, but within two days, the wound turned black and gangrenous [Figure 31].

Wound assessment

The wound was assessed using T.I.M.E [Table 14]. The wound was found to be infected, and the patient was started on empiric antibiotic therapy with Meropenem (500 mg intravenously every 12 hours) and Clindamycin (600 mg intravenously every 8 hours). Upon re-evaluation, peripheral pulses were absent in both lower extremities and an ankle-brachial index (ABI) of 0.2 in the right and 0.3 in the left leg.

To restore perfusion, the patient underwent revascularisation using a hybrid approach that combined endovascular therapy and open bypass surgery [Figure 32]. While awaiting the revascularisation procedure, dry dressings were applied to the wound to maintain stability and limit contamination.

Approximately one week after revascularisation, perfusion of the right foot was assessed using indocyanine green fluorescence imaging, confirming adequate perfusion to the wound bed and surrounding skin.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 15]. Intended treatment outcomes were to: prepare the skin for skin grafting.

Wound review

Week 1–4

During the first four weeks, dressings were changed daily.

Week 5

From week 5 onwards, dressing changes were changed every other day by a wound care nurse specialist at the wound clinic.

Week 6

By week 6 [Figure 34], the wound had reduced significantly in size compared to its presentation during the first week.

Table 14. Wound assessment using the T.I.M.E acronym

Tissue	Gangrene, devitalised tissue; pale and dry wound base
Infection	Signs of infection (slough, pain, oedema); already on medication
Maceration/ Moisture	N/A
Edges	N/A

Table 15. Wound Hygiene intervention

Cleanse 	During the first week, the wound bed was cleansed with saline and povidone-iodine solution to manage infection and prevent further contamination. Once the infection subsided, saline alone was used to avoid irritation. During outpatient care, the wound was cleansed with an irrigation solution containing betaine and PHMB, which helps achieve a clean wound bed and surrounding skin.
Debride 	During the initial 2–3 sessions, sharp debridement was performed in the operating room to remove gangrenous and devitalised tissue, as the patient experienced significant pain during the procedure **[Figure 33a and 33b]**. After the extensive gangrenous and devitalised tissue was excised, leaving only small areas of necrotic tissue in the wound bed, the patient could tolerate bedside debridement. As the wound infection resolved, dry necrotic tissue in the wound bed was treated with a hydrocolloid gel to promote autolytic debridement and aid the natural breakdown of non-viable tissue.
Refashion 	Wound edges were refashioned once a week using a blade and scissors. A wound specialist nurse cleansed the wound bed and periwound edges daily using a soft debridement gauze wipe.
Dress 	Aquacel Ag+ Extra was applied to the wound as the primary dressing to reduce and prevent biofilm reformation due to the bacterial load. Gauze was applied as a secondary dressing.

Week 7

At week 7, the patient underwent amputation of the tip of the right first toe. Aquacel Ag+ Extra continued to be used as part of the Wound Hygiene protocol. Wound healing progressed, and the wound was fully closed five months after initial presentation, with skin grafting completed two weeks prior [Figure 35].

Discussion

In this case, ischemic wound revascularisation was performed first. This was followed by the application of the Wound Hygiene protocol, which included cleansing, debridement to remove gangrenous and devitalised tissue, refashioning wound edges, and dressing the wound. These

Case 7: Chronic limb-threatening ischaemia, presented with necrotising fasciitis

Figure 31. Wound on presentation

Figure 32. Week 1 post-revascularisation. (a) Dorsal and (b) lateral view of the right foot

Figure 33. Wound after the first session of sharp debridement: (a) dorsal aspect, (b) lateral aspect of the right foot

Figure 34. Week 6, with a significant reduction in wound size compared to initial presentation

Figure 35. Week 22 post-treatment and revascularisation, shown two weeks after skin grafting

CASE 8: Leg ulcer resulting from trauma

Authors: **Dr Kazutaka Soejima**, Professor, Department of Plastic Surgery, Nihon University School of Medicine, Tokyo, Japan; **Dr Shun Okamoto**, Department of Plastic Surgery, Nihon University School of Medicine, Tokyo, Japan

Patient presentation and history

A 79-year-old female sustained a contusion on her left lower leg following a fall from a bicycle, which resulted in a haematoma and subsequent necrosis [Figure 36]. Despite initial debridement and conservative treatment with ointment provided by a previous physician, no improvement was observed. The patient was referred to the authors' department 27 days post-injury. Although hospitalisation was recommended, the patient preferred outpatient care.

Wound assessment

The wound was assessed using T.I.M.E [Table 16]. The wound measured 12cm (length) x 13cm (width), with no depth.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 17]. Intended treatment outcomes were to prepare the wound for skin grafting.

Discussion

Aquacel Ag Advantage was applied three times a week in an outpatient setting. Within four weeks, wound closure was achieved without the need for skin grafting. No hypertrophic scarring was observed. This approach avoided hospitalisation and surgery, improving the patient's quality of life. It was the ideal outcome, as the patient was hesitant to attend the hospital. Ointment treatment was initiated thereafter.

Aquacel Ag Advantage[1] proved effective for outpatient care, with dressing changes occurring every few days. These changes were managed by healthcare professionals, the patient or their family members, enabling self-care at home. Regular debridement and edge refinement were important during outpatient visits. Despite the absence of conditions such as diabetes or lower limb ischaemia, the chronic, non-healing wound responded significantly to the Wound Hygiene protocol, resulting in successful wound healing.

Table 16. Wound assessment using the T.I.M.E acronym

Tissue	Wound bed comprised of white devitalised tissue
Infection	No signs of infection on visual inspection and initial wound bacterial culture yielded negative results
Maceration/ Moisture	Moist wound bed with high levels of exudate
Edges	White necrotic tissue attached to wound edges

Table 17. Wound Hygiene intervention

Cleanse 	Due to the presence of devitalised tissue, the wound bed and surrounding skin was thoroughly cleansed using a surfactant cleansing solution.
Debride 	Following cleansing, any remaining devitalised tissue was removed with a curette [Figure 37a and 37b].
Refashion 	Wound edges were refashioned by scraping away soft necrotic tissue with a dermal curette and freshening the edges with scissors.
Dress 	The wound was dressed with Aquacel Ag Advantage to prepare the wound bed. The dressing was changed three times a week [Figure 38] and regular cleaning, debridement and edge refreshment was performed [Figures 39 and 40]. By week 4, epithelialisation had progressed, and skin grafting was no longer necessary [Figure 41].

Aquacel Ag Advantage is the brand name used in Japan. In other countries, this product is marketed as Aquacel Ag+ Extra.

Case 8: Leg ulcer resulting from trauma

Figure 36. During the initial consultation

Figure 37. (a) Lower leg wound pre- and (b) post-debridement

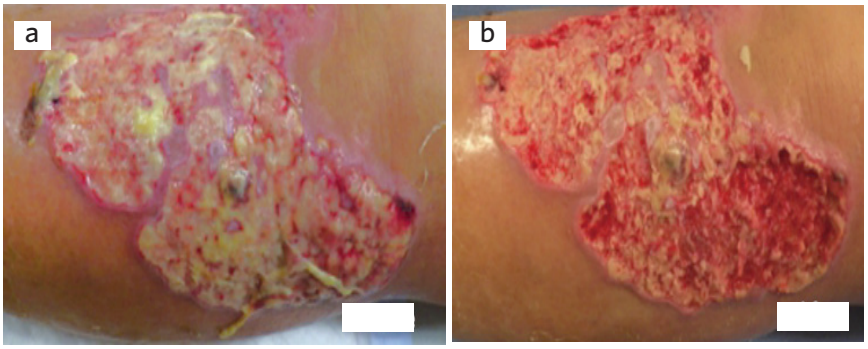


Figure 38. Appearance of slough and necrotic tissue trapped in Aquacel Ag Advantage provides cleansing with each replacement

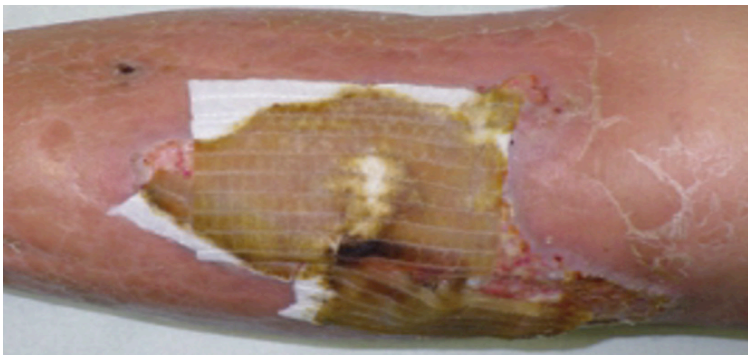


Figure 39. Week 1 of treatment with Aquacel Ag Advantage

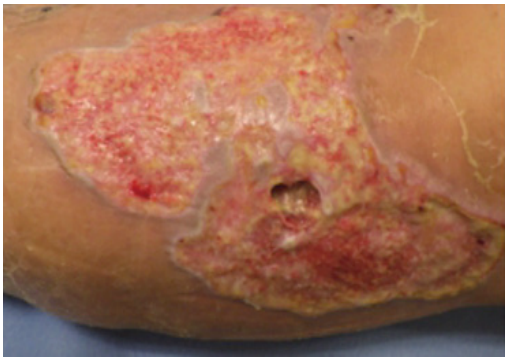


Figure 40. Week 2 of treatment with Aquacel Ag Advantage

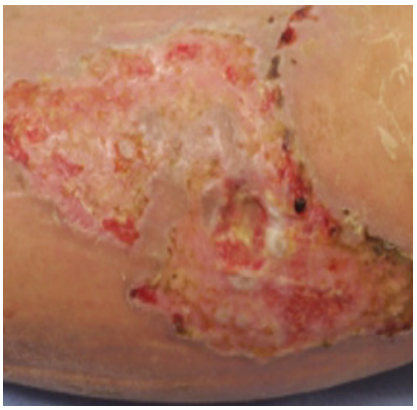


Figure 41. Week 4 of treatment with Aquacel Ag Advantage

CASE 9: Lower limb severe deep soft tissue infection

Author: **Dr Wuttichai Saengprakai**, Assistant Professor, Vascular Surgeon, Division of Vascular and Endovascular Surgery, Faculty of Medicine, Navamindradhiraj University, Bangkok, Thailand

Patient presentation and history

A 59-year-old female presented with swelling and pain in her right foot, which began two days after she scratched the dorsal aspect. The patient's medical history included type 2 diabetes mellitus and hypertension. On examination, she had a fever of 39°C, low blood pressure (90/60 mmHg) and leukocytosis, with a white blood cell count of 19,000 cells/×l.

Wound assessment

The wound was assessed using T.I.M.E [Table 18]. The patient was diagnosed with a deep soft tissue infection affecting the right lower leg and dorsum of the foot. All lower extremity pulses were palpable, with no evidence of chronic venous insufficiency. Broad-spectrum intravenous antibiotics, specifically piperacillin/tazobactam, were administered following blood sample collection for haemoculture.

Wound Hygiene intervention

The Wound Hygiene protocol, which includes four key steps of cleansing, debridement, refashioning and dressing application, was implemented at each dressing change [Table 19]. Intended treatment outcomes were to: prepare the skin for skin grafting.

Wound review

Week 1

In week 1, the wound was managed with saline-soaked gauze (wet dressing) to maintain a moist environment and support wound healing. Sharp debridement was performed in the operating room until week 5, with daily bedside debridement helping to remove slough and necrotic tissue.

Weeks 2–4

Negative pressure wound therapy (NPWT) was introduced to help improve tissue granulation [Figure 44]. It was continued until week 8, and at this point, dressings were changed daily to manage exudate levels and prevent infection.

Week 5

As necrotic tissue burden decreased, the frequency of dressing changes was adjusted from daily to every two to three days.

Week 8

By week 8, granulation tissue had filled the wound bed. Aquacel Ag+ Extra was introduced as the primary dressing, with Aquacel foam adhesive used as the secondary dressing.

Table 18. Wound assessment using the T.I.M.E acronym

Tissue	Gangrene, devitalised tissue; pale and dry wound base
Infection	Signs of infection (slough, pain, oedema); already on medication
Maceration/ Moisture	No maceration, dry wound bed
Edges	Devitalised tissue

Table 19. Wound Hygiene intervention

Cleanse 	After initial sharp debridement in the operating room **[Figure 42]**, the wound bed was cleansed with saline, and povidone-iodine solution was applied to the surrounding skin. This cleansing protocol was maintained during subsequent outpatient care.
Debride 	Despite initial debridement, necrotic and infected tissue remained in the wound. To address this, sharp debridement with a blade and scissors was performed under IV sedation in the operating room once a week for the first five weeks **[Figure 43]**. Daily bedside debridement using scissors was performed to manage persistent necrotic tissue. Once the necrosis was resolved, hydrocolloid gel was introduced to the treatment regimen to facilitate autolytic debridement.
Refashion 	Wound edges were refashioned with a blade and scissors both in the operating room and at the bedside. During outpatient wound care, the wound specialist nurse used a soft debridement gauze to clean the wound bed and surrounding skin during each dressing change.
Dress 	Saline-soaked gauze (wet dressing) was applied to the wound to maintain a moist wound healing environment. NPWT was then initiated over the wet gauze.

The wound was covered with gauze for added protection. At this stage, the patient was discharged for outpatient care, with dressing changes performed every three days.

Week 11

During outpatient wound care, the Wound Hygiene protocol was rigorously maintained at every dressing change. By week 11, exudate levels had significantly reduced, allowing for a transition to Aquacel Ag+ Extra as sole dressing [Figure 45].

Week 12

Weekly follow-ups ensured close monitoring of the wound's progress, leading to near-complete wound closure by week 12.

Discussion

The patient's wound demonstrated improvement with a structured treatment protocol, starting with sharp debridement to remove necrotic tissue and progressing with NPWT and Aquacel Ag+ Extra to promote wound healing. Once granulation tissue formed, the option of skin grafting was discussed. After obtaining consent, a consultation with a plastic surgeon was arranged, and the procedure was successfully performed Complete wound healing was achieved two weeks after the skin grafting [Figure 46].

Case 9: Lower limb severe deep soft tissue infection

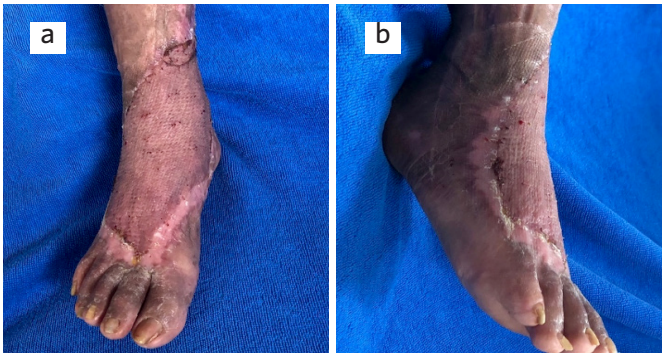
Figure 42. Wound following first session of debridement in the operating room

Figure 43. Wound with necrotic tissue during the first five weeks of treatment. (a–b) Pre-debridement appearance; (c–d) post-debridement following removal of devitalised tissue

Figure 44. Week 2 of Wound Hygiene (a) wound pre and (b) post-debridement

Figure 45. (a) Week 8 and (b) week 9 of Wound Hygiene

Figure 46. Complete wound closure achieved through skin grafting by week 14. (a) Frontal and (b) lateral view of the foot



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