Maintaining skin integrity in diabetic foot ulcer care: the role of Appeel® Sterile

Effective healing of diabetic foot ulcers (DFUs) relies heavily on maintaining the integrity of the periwound skin, as this area serves as a protective barrier that supports wound healing and prevents infection (Newton et al, 2018). However, skin changes associated with diabetes, such as thickening, stiffening and reduced elasticity, increase the fragility of the periwound skin, leading to delayed healing (Moraes, 2023) and a higher risk of complications, including medical adhesive-related skin injuries (MARSIs). This article explores the causes of ulceration, delayed wound healing and increased skin fragility, and discusses the benefits of using sterile medical adhesive removers such as Appeel® Sterile (CliniMed Ltd.), to maintain skin integrity, prevent further skin damage, reduce infection risk and promote improved healing outcomes for DFUs.

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- Appeel® Sterile
- Diabetic Foot Uler
- MARSI
- Skin integrity

The global burden of diabetic foot ulcers (DFUs) is a significant concern. Of the estimated 537 million people living with diabetes worldwide, between 19% and 34% are expected to develop a DFU in their lifetime (McDermott et al, 2023). The impact of DFUs go beyond physical complications, negatively affecting patients' overall health and wellbeing. A study by Van Acker et al (2014) highlighted that individuals with active or recurrent DFUs experience significant reductions in physical and social functioning. This challenges the common misconception that pain is not a major issue in foot ulceration. In reality, pain, social isolation and a reduced ability to work all contribute to a lower health-related quality of life (HRQoL).

In addition to the human cost, DFUs place a significant financial burden on healthcare systems. Kerr et al (2019) estimated that DFU management costs the UK National Health Service (NHS) approximately £1 billion annually, representing around 10% of total diabetes-related spending.

Diabetes and the foot: aetiology and risk factors

Neuropathy and peripheral arterial disease (PAD) are among the most common complications of diabetes that contribute to the development of DFUs. Diabetic neuropathy, particularly sensory peripheral neuropathy, results in a loss of protective sensation, making it difficult for patients to detect minor injuries or damage to their feet (Monteiro-Soares, 2023). As a result, this absence of pain can delay detection and treatment. PAD, characterised by atherosclerotic narrowing of the arteries, can develop alone or alongside neuropathy.

It often remains undiagnosed until it progresses to chronic limb-threatening ischaemia, a condition marked by severe rest pain, gangrene or ulcers that do not heal within two weeks (Conte et al, 2019). The combination of PAD and neuropathy significantly increases the risk of developing a DFU which, in turn, increases the likelihood of infection and limb amputation (Crawford et al, 2015). The combination of PAD and neuropathy significantly raises the risk of ulceration, infection and subsequent amputation (Crawford et al, 2015).

Infections in diabetic foot care

Diabetic foot infections are serious complications of diabetes that often require hospitalisation and represent the leading cause of lower-extremity amputations (International Working Group on the Diabetic Foot [IWGDF], 2023). The increased risk of infection, particularly in those with neuropathy or PAD, highlights the importance of effective prevention and management strategies to mitigate severe outcomes, such as sepsis and amputation (IWGDF, 2023; NICE, 2024).

Patients with neuropathy are at especially high risk of infection, as the loss of sensation may result in both clinicians and patients overlooking early signs of injury and infection (Monteiro-Soares, 2023). While complete neuropathy results in a total loss of sensation, partial neuropathy may still allow some pain response, making it difficult to assess the true extent of foot damage (Pop-Busui et al, 2017).

Declaration of interest
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Skin changes in diabetes

Diabetes is associated with a range of skin changes that compromise barrier function, including:

- Accelerated skin ageing and the production of advanced glycation end products, which cause irreversible damage to collagen fibres (Moraes et al, 2023)
- Reduced skin elasticity (Moraes et al, 2023)
- Skin thickening and stiffness, especially on hands and feet (Newton et al, 2018; Kaltheuner et al, 2018)
- Delayed wound healing and reduced skin integrity (Moraes et al, 2023)
- Skin discolouration.

These skin changes make patients more vulnerable to injury and infection. When the skin barrier is compromised, the risk of developing serious conditions like sepsis increases (Alexiou and Rau, 2023). This is especially important in people with diabetes, where skin changes combined with reduced sensation (peripheral neuropathy) place them at greater risk of skin breakdown.

One area of concern is the use of adhesive dressings for DFUs. These dressings need to stay in place for long periods, but their strong adhesive can make removal painful and potentially damaging to fragile skin. This can lead to medical adhesive-related skin injury, known as MARSI, which refers to any skin damage caused by medical adhesives, such as skin stripping, blistering or tearing.

To help prevent MARSI and minimise discomfort during dressing changes, podiatrists often use sterile medical adhesive removers. These products loosen the adhesive bond, allowing the dressing to be removed without causing further trauma to the skin.

What is a MARSI?

A MARSI occurs when the adhesive properties of medical products, such as dressings, tapes, electrodes, medication patches or wound closure strips, damage the skin. This damage can range from mild irritation to more serious injuries like skin stripping, blistering or skin tears [Table 1].

A MARSI typically happens during the removal of these products. Adhesives, particularly acrylic-based ones commonly used in medical products, form strong bonds with the skin that can strengthen over time. While this strong adhesion is necessary to keep dressings or devices securely in place, it can also increase the risk of skin damage when the product is removed. The bond can be so strong that removing the product can traumatically pull on the skin, leading to a MARSI.

Table 1. Causes of MARSIs (Fumarola et al, 2020).

Mechanical forces
Skin stripping: superficial removal of one or more layers of epidermal cells. The skin may appear shiny and lighter than the surrounding areas
Skin tears: separation of skin layers from epidermis to dermis. Can be partial-thickness or full-thickness
Tension blisters: blistering
Dermatitis
Non-allergic irritant contact dermatitis: localised inflammation. The skin may appear 'red' and swollen. Vesicles may form
Allergic dermatitis: local/systemic inflammatory response. The skin may appear 'red', inflamed, blistered and itchy
Other
Folliculitis: local infection, rash, raised bump and pustules

These injuries can occur across various age groups and clinical settings (de Faria et al, 2022), particularly when correct techniques for applying and removing adhesive dressings or devices are not followed. Although all populations and clinical settings that use medical adhesives are at risk of a MARSI, especially with an increased frequency of exposure, certain patient groups are particularly vulnerable, including (Wounds UK, 2018; 2023):

- People with diabetes
- Extremes of age (paediatric or elderly patients)
- People with cancer
- People with dermatological conditions (e.g. eczema or psoriasis)
- People with oedema or whose skin is exposed to bodily fluids (e.g. urine, faeces, wound exudate or sweat) for prolonged periods
- People with fragile skin.

MARSI can cause significant pain, increase the risk of infection, prolong hospital stays and raise healthcare costs (Fumarola et al, 2020).

Skin stripping, a common type of MARSI, can lead to painful partial-thickness skin damage, which compromises the skin's barrier function (Fumarola et al, 2020; Thayer, 2021; Bernatchez and Bichel, 2023; Figure 1). Once the epidermis has become compromised, the risk of infection is increased (International Wound Infection Institute, 2022) and is associated with pain and discomfort (Matsumura et al, 2012; Hofman et al, 2023).

A single-centre observational study in an adult acute care setting conducted by Farris

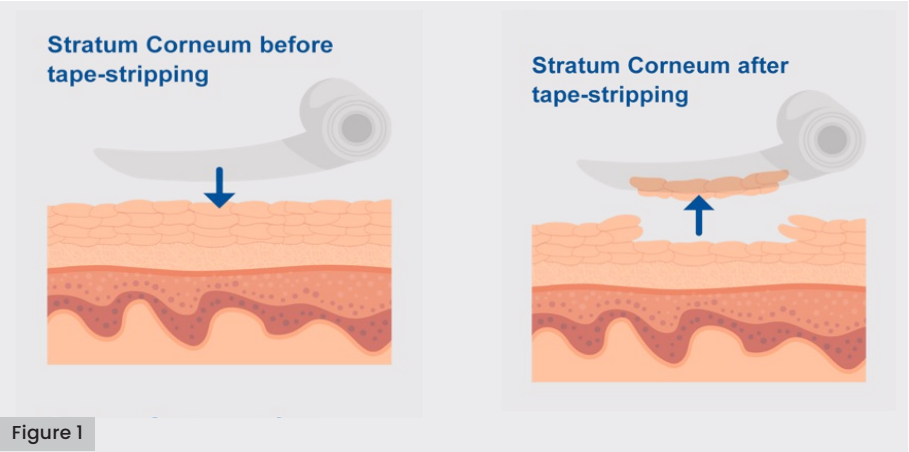

Figure 1

Figure 1. Effects of tape stripping on the stratum corneum. (a shows the intact stratum corneum layer before tape-stripping, where the adhesive is securely attached. (b) shows disruption of the stratum corneum after tape-stripping, demonstrating the removal of the skin's outermost layer

et al (2015) reporting prevalence of MARSI found that daily prevalence ranged from 3.4% to 25%, with a mean 13%. Yet, MARSI is largely preventable with appropriate preventive measures, including the use of medical adhesive removers.

For at-risk patients, such as those with diabetes, a suitable skincare regimenn is essential for maintaining skin integrity [see Table 2]. This should include the use of skin protectors and medical adhesive removers, particularly sterile silicone medical adhesive removers, which have been shown to reduce infection risk, minimise the need for analgesia and decrease nursing time and costs (Fumarola et al, 2020).

Appeel® Sterile Medical Adhesive Remover

The use of a sterile medical adhesive remover, such as Appeel® Sterile Medical Adhesive Remover, is a key recommendation for clinical practice (Fumarola et al, 2020) particularly for patients with diabetes. It effectively removes adhesive and barrier film residues to minimise discomfort and skin damage, especially during dressing changes.

Appeel® Sterile is a non-sting medical adhesive remover that contains healthcare-grade silicone. Its formulation works by penetrating the space between the adhesive layer of the dressing or medical device and the patient's skin to temporarily alter the surface energy of the skin. This mechanism loosens the adhesive bond, to allow for the safe and painless removal of dressings without compromising the integrity of the surrounding skin (Wounds UK, 2023). In a study of 155 patients, 85% experienced a significant reduction in pain or no pain at all when using Appeel® Sterile (CliniMed, 2010).

Appeel® Sterile products are fast-drying and leave no residue, ensuring quick and easy removal while preventing the accumulation of detritus around the periwound skin.

Appeel® Sterile is the only range of fully sterile medical adhesive removal products currently available in the United Kingdom and can be used on both intact and injured skin. It is especially beneficial for patients at significant risk of infection, such as those with open wounds, intravenous access sites/central lines and immunocompromised/suppressed individuals — e.g. people with diabetes.

The product is easy to use and is available in a variety of formulations designed to suit a range of wound aetiologies. The range includes:

Table 2. A skin care regimenn (Fumarola et al, 2020).

What to consider in a skin care regimenn:
Use pH neutral soap substitute to wash; avoid alcohol-based fragrances/washes; pat dry instead of rubbing skin
Hydrate the skin using moisturisers and use emollients as a moisture barrier; ensure patient drinks fluids to avoid dehydration
Handle skin with care; avoid clothing that causes irritation or itching
Advise skin protection when in the sun, e.g., sun hat, sunscreen with a minimum factor of 30
Use a skin protector and a sterile medical adhesive remover, e.g. Appeel® Sterile, if applying any medical dressings or devices.

Table 3. Indications and examples for use of the Appeel® Sterile medical adhesive remover range.

Appeel® Sterile Wipe
- Single use only
- **Indications:** Removal of small medical adhesive products without damaging the skin
- **Common application sites:** Removal of adhesives around nasogastric or endotracheal tubes in general clinical settings

Appeel® Sterile Foam Applicator
- Single use only
- **Indications:** Removal of small medical adhesive products where precision is required. Enables patients to be involved in their own dressing removal process
- **Common application sites:** Areas where small fixation devices or tapes are applied, such as around toe separators, silicone toe props, intravenous cannulae or central lines, as well as on delicate skin, including in paediatric patients or on the face

Appeel® Sterile Liquid Sachet
- Single use only
- **Indications:** Removal of larger medical adhesive products where pain, periwound trauma or infection are of concern
- **Common application sites:** Removal of adhesives around the abdominal and spinal area

Appeel® Sterile Spray
- Single patient; multiple use (e.g. in community settings)
- **Indications:** Removal of medical adhesive products in difficult-to-reach areas. Uses "Bag-on-Valve" technology to provide 360-degree coverage, avoiding awkward positioning without causing any cold sensation
- **Common application sites:** Removal of adhesives around sensitive or fragile skin, such as the heel, particularly in diabetic foot wounds. As well as the entire foot surface when removing layered padding, including orthopaedic felt or fixation tape

- Appeel® Sterile Liquid Sachet
- Appeel® Sterile Wipe
- Appeel® Sterile Foam Applicator
- Appeel® Sterile Spray (100ml).

Appeel® Sterile range in practice

The Appeel® Sterile range offers versatile options for skin care for people who have diabetes. The Appeel® Sterile wipe and foam applicator are ideal for removing small dressings. These products allow patients to be involved in their own dressing changes, fostering autonomy in care. Self-care positively impacts pain management, flexibility associated with patients' own treatment regimen and the empowerment associated with being in control; responsibility for their own health also positively impacts patient HRQoL (Kapp and Santamaria, 2020). Patients who are involved in self-care gain a sense of control and responsibility over their health. This empowerment can enhance their overall well-being and engagement in wound care tasks like cleaning, dressing, and monitoring for infection (Blackburn and Ousey, 2023). The foam applicator enables precise removal in delicate areas, such as the periwound region in DFUs, where careful management of skin integrity is essential.

For larger dressings, the Appeel® Sterile Liquid sachet is an excellent choice. Its controlled delivery through a "pinch-top" technique ensures precise application, making it suitable for keeping the periwound area dry, which is critical for infection prevention in people with diabetes. The liquid sachet is cost-effective, as one sachet can efficiently remove large dressings using a start-and-stop technique, which is beneficial when dealing with fragile periwound skin.

A unique product in the Appeel® Sterile range is the single patient/multi-use spray. This spray is particularly useful for hard-to-reach wounds, such as diabetic foot or heel wounds. Its "Bag-on-Valve" technology allows 360-degree coverage, enabling healthcare professionals to apply it easily without awkward positioning. Notably, the spray does not cause a 'cold sensation' upon application, enhancing patient comfort. Ultimately, using a sterile medical adhesive removal product will assist

in preventing periwound skin damage and reducing pain and discomfort experienced during dressing or medical device removal (Fumarola et al, 2020; Hitchcock et al, 2021). The product range and indications for use are summarised in Table 3.

Case study

The following case studies demonstrate the clinical application of Appeel® Sterile in supporting atraumatic dressing removal for patients with fragile skin, a common challenge in wound management. These examples illustrate Appeel® Sterile's efficacy in reducing skin trauma and patient discomfort during dressing changes, particularly in individuals with underlying conditions such as diabetes and PAD.

Case 1, presented by Andrew Sharpe, Advanced Podiatrist and Academic Fellow in Podiatry at Northern Care Alliance NHS Foundation Trust, describes the use of Appeel® Sterile Spray to prevent skin stripping during dressing changes. Following its introduction, the patient's reported pain decreased significantly, with Visual Analogue Scale (VAS) scores reducing from 8/10 to 3/10.

Cases 2 and 3, presented by Susan Artress-Brown, Principal Podiatrist and Diabetes Specialist Podiatrist at Hampshire and Isle of Wight Healthcare NHS Foundation Trust, demonstrate further applications of Appeel® Sterile. In Case 2, it enabled atraumatic removal of strongly adherent padding from bruised, vulnerable skin, where previous attempts caused microtears and discomfort despite neuropathy. In Case 3, it was essential for a patient with severe ischaemia and pain sensitivity, where conventional removal methods were stopped due to skin damage risk and intolerable pain.

Case study 1: Management of a diabetic foot ulcer in an elderly patient with peripheral arterial disease

An 82-year-old female patient with type 2 diabetes and PAD presented with a necrotic DFU located on the lateral aspect of her left foot, specifically between the fourth and fifth toes [Figure 2]. The skin surrounding the DFU was dry and fragile, due to autonomic skin changes associated with diabetes and age-related thinning.

Her compromised skin was particularly vulnerable to skin stripping during dressing changes, which contributed to the significant pain she experienced during these procedures. She reported pain levels of 8/10 on the Visual Analogue Scale (VAS; 0 = no pain; 10 = unbearable pain).

Due to the patient's underlying PAD, surgical intervention was not an option. To reduce pain and prevent further skin damage, a new gentle and atraumatic strategy was implemented. Appeel® Sterile Spray was introduced to lift and remove dressings without causing trauma to the skin. In conjunction, a non-adherent, low-adhesive dressing was applied to maintain a moist wound environment and enhance patient comfort. Regular monitoring was carried out to prevent infection.

Over the course of two weeks, consistent use of Appeel® Sterile Spray resulted in significant improvements in pain management. Pain during dressing changes reduced from a VAS score of 8/10 to 3/10, and the surrounding skin remained intact, with no signs of infection [Figure 3]. Additionally, the patient's anxiety around dressing changes decreased, contributing to an overall improvement in her experience.

This case highlights the importance of using a sterile medical adhesive remover (e.g. Appeel® Sterile) for DFUs in patients with fragile skin, especially when pain and infection risk are heightened. Gentle removal of dressings with Appeel® Sterile helped to minimise trauma, reduce pain, and support infection prevention.

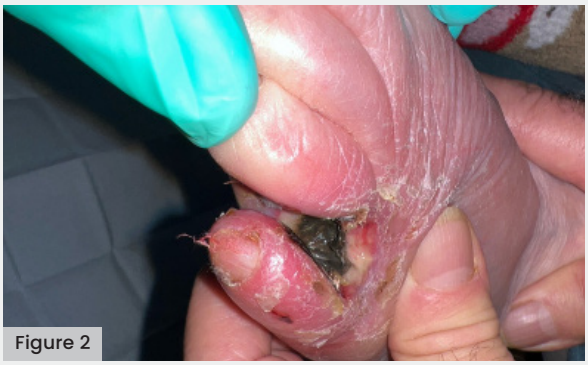

Figure 2. Necrotic DFU located on the lateral aspect of the left foot before use of Appeel® Sterile. The surrounding skin appears dry and fragile, consistent with autonomic skin changes related to diabetes and age-related thinning

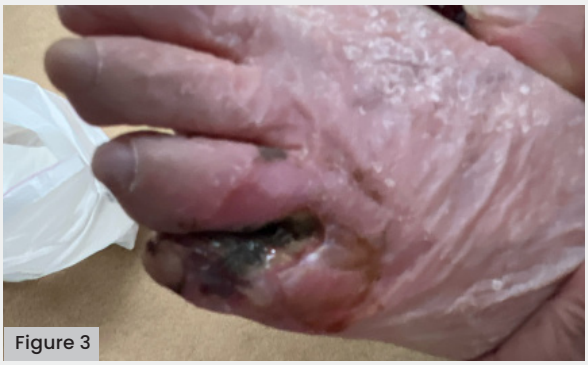

Figure 3. Appearance of the necrotic DFU after two weeks of dressing removal with the aid of Appeel® Sterile Spray. The surrounding skin remains intact and shows improved condition, with no signs of infection

Case study 2: Use of a medical adhesive remover to protect fragile skin in a patient with partial neuropathy

A 59-year-old male presented with a superficial wound over the left first metatarsophalangeal joint. The surrounding tissue appeared bruised, with no clinical signs of infection. The wound was believed to have developed as a result of the patient's foot sliding within his bespoke orthopaedic footwear. Due to partial diabetic neuropathy, the patient had been unaware of the issue.

The patient's comorbidities included type 2 diabetes mellitus, diabetic neuropathy, hypertension, hypercholesterolaemia and gastro-oesophageal reflux disease.

The wound was non-probing, with the area of damaged tissue measuring approximately 3cm x 3cm. However, the open wound itself measured only 5mm x 5mm. Tissue composition included 97% friable, vulnerable skin, with 3% maceration and a small open area of granulating tissue. No slough was present.

Despite his neuropathy, the patient experienced discomfort during the removal of adhesive padding and dressings. Soaking the affected area in warm water for a minimum of 20 minutes failed to loosen the adhesive sufficiently [Figure 4], resulting in micro skin tears [Figure 5]. The clinical team introduced Appeel® Sterile Spray (100ml) as a single-patient, multiple-use product. This method proved significantly more effective, allowing for atraumatic removal of dressings without subsequent skin trauma or tears [Figure 6].

No analgesia was required at the time of removal, and the patient reported a pain level of 5/10 on the VAS. With continued use of Appeel® Sterile Spray, the patient became unaware that the padding was being removed, reporting no pain or irritation. Appeel® Sterile Spray was easy to apply, and to prevent the risk of slipping during application, couch roll was placed under the foot as a precaution. This case illustrates how Appeel® Sterile Spray can enable atraumatic dressing changes in patients with fragile skin, helping to preserve skin integrity and improve the overall patient experience.

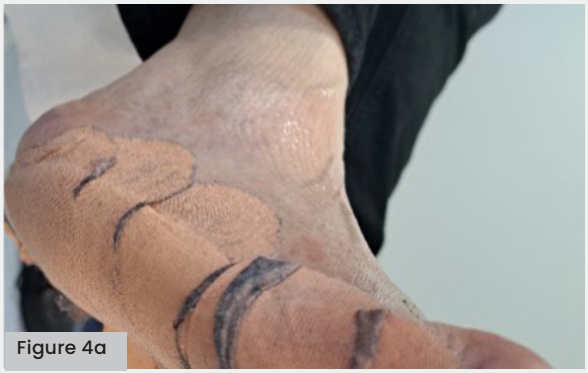

Figure 4a

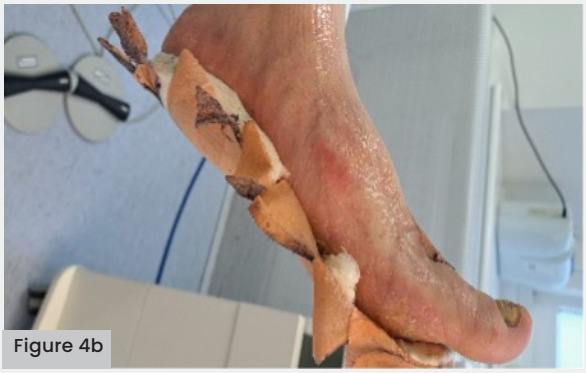

Figure 4b

Figure 4. Condition of the foot following a 20-minute soak in warm water, prior to the use of Appeel® Sterile Spray. Removal of adhesive padding and dressings was attempted but achieved limited success

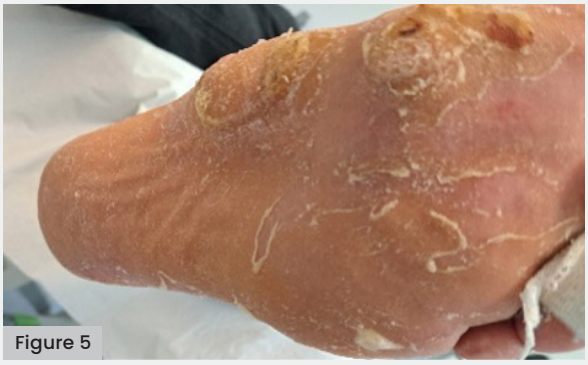

Figure 5

Figure 5. Post-removal of padding, with visible skin tears resulting from the attempt to remove adhesive padding and dressings without an adhesive remover

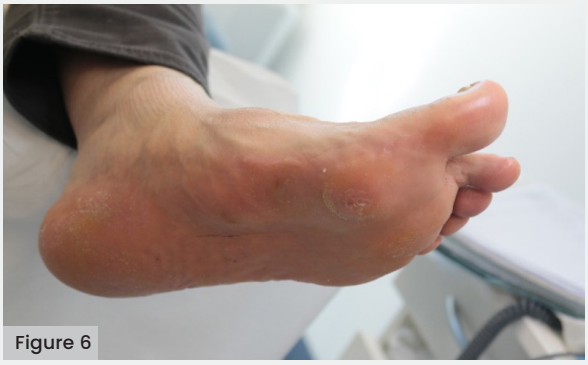

Figure 6

Figure 6. Application of Appeel® Sterile Spray to support atraumatic removal of padding and dressings, following initial healing of skin tears

Case study 3: Atraumatic dressing removal in a patient with ischaemic pain and fragile skin

A 67-year-old male patient presented with an open wound on the right fifth metatarsophalangeal joint (5th MTPJ) and a tender pressure area on the medial aspect of the calcaneus. While the wound on the fifth MTPJ was open, the skin over the calcaneus remained intact. No clinical signs of infection were observed.

The patient's comorbidities included type 2 diabetes mellitus, severe kidney disease, diabetic neuropathy, diabetic peripheral angiopathy with ischaemia in both feet and legs and hypertension.

The wound was believed to have developed due to ill-fitting new footwear. As a result of ischaemic pain and diabetic neuropathy, the patient had not recognised the issue until it had progressed.

The wound probed to a depth of 5mm, and the open area measured 6mm × 1cm. The tissue composition included 90% friable, vulnerable skin, 5% maceration and 5% granulating tissue, with a small amount of slough present in the wound bed.

During dressing removal, the patient experienced severe pain due to ischaemia, despite having soaked the padding in warm water for over 20 minutes [Figure 7]. The level of discomfort necessitated stopping the removal process to avoid further trauma. Although he had been advised to take oral morphine before the appointment, his pain was rated 9/10 on the VAS.

To enable safe and atraumatic dressing removal, Appeel® Sterile Spray (100ml) was introduced as a single-patient, multiple-use product. Appeel® Sterile Spray facilitated the painless removal of adhesive padding and dressings without causing trauma or skin tearing [Figure 8]. With its use, the patient reported minimal to no discomfort and was largely unaware that the dressing was being removed.

Appeel® Sterile Spray was easy to apply, and to prevent slippage, couch roll was placed beneath the foot as a precautionary measure.

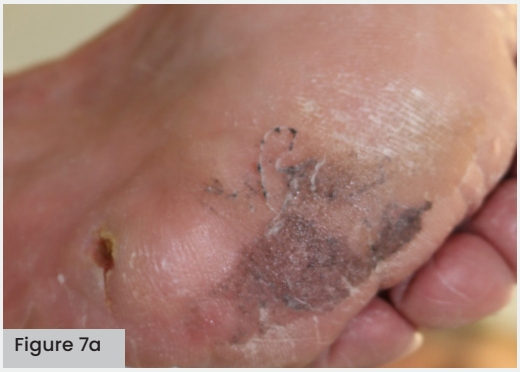
Figure 7a

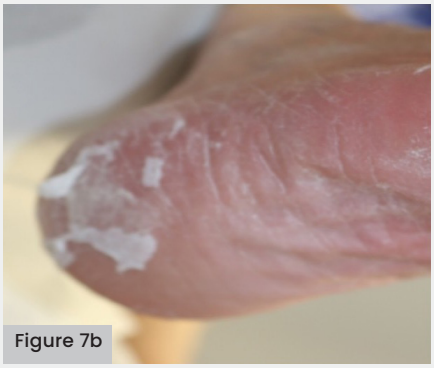
Figure 7b

Figure 7. Adhesive residue clearly visible on the plantar aspect of the foot following attempted dressing removal. Despite soaking the area in warm water for over 20 minutes in warm water, the adhesive could not be fully removed, and dressing removal remained painful and incomplete

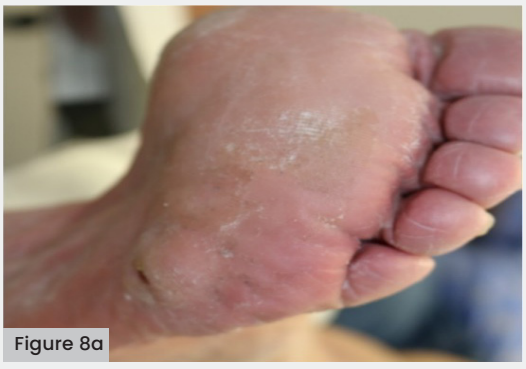
Figure 8a

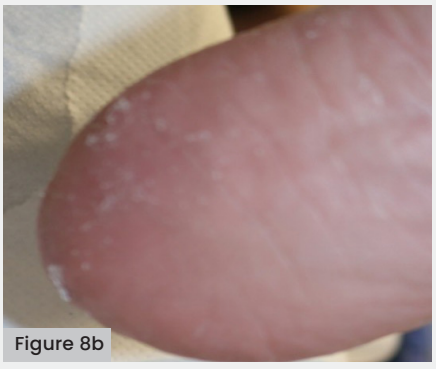
Figure 8b

Figure 8. Following application of Appeel® Sterile Spray, adhesive dressings were successfully removed with minimal discomfort. No further trauma to the skin was observed, and no visible adhesive residue remained on the skin surface

Conclusion

In patients with diabetes and PAD, maintaining skin integrity and preventing infection are essential to avoid further deterioration. The use of Appeel® Sterile Medical Adhesive Remover can significantly reduce pain and skin trauma during dressing changes, thereby contributing to improved patient outcomes and enhanced adherence to treatment plans.●

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