

Impact of adhesive surgical tape and wound dressings on the skin, with reference to skin stripping

Age- and disease-related factors can cause the skin to become susceptible to damage, particularly at dressing change. This review recommends ways of avoiding skin trauma when removing adhesive dressings and surgical tapes

review; skin stripping; adhesive tapes; adhesive dressings; soft silicone dressings

Care of the skin, including its protection against mechanical/chemical injury, is a requirement for those involved in dermatological care. Tissue trauma, caused by the removal of adhesives tapes and dressings, can exacerbate pain, increase wound size and delay healing, thereby increasing health-care costs and reducing patients' quality of life.¹ Adhesives can either be separate entities (eg, tapes) or an integral component of a dressing (eg, incorporated over the entire dressing surface or around the central absorptive pad).

This article briefly describes how age- and disease-related pathological changes can adversely affect skin integrity. It then focuses on trauma (skin stripping) related to the use of adhesive surgical tapes and wound dressings, and the potential impact on patients, particularly those with ageing skin and/or skin that has been compromised by disease. Following a review of experimental and clinical data, recommendations are given on how to avoid these problems.

The literature search

Searches of bibliographic databases (Medline 1950–2008 and Embase 1974–2008), the Cochrane Library and *World Wide Wounds* websites, and journals relating to dermatology and wound management were undertaken to identify relevant data. The following search terms were used: 'skin' and ['structure' or 'morphology' or 'function' or 'physiology'] and ['abnormality' or 'defect' or 'damage' or 'injury' or 'lesion' or 'trauma' or 'ulcer' or 'wound'] and ['aging' or 'disease'] and 'adhesive' and ['tape' or 'dressing'].

Age-related pathological changes to skin

Skin integrity is adversely affected by both age-related and disease-related pathologies.

Progressive detrimental changes, caused primarily by cumulative exposure to harmful ultraviolet wavelengths in sunlight, occur in the skin with ageing.

Progressive changes lead to epidermal hyperplasia and neoplasia, with concomitant dermal changes including enhanced inflammatory processes, elastosis and reduction of cutaneous vessel size.^{2,3} Changes in the mechanical properties of skin, in particular tissue hydration and its resiliency, are intimately linked with age. Skin can show a tendency for decreased blood flow with increasing age.^{4,5}

Disease-related pathological changes to skin

Various pathological conditions, affecting both adults and children, have an adverse effect on skin structure and function. Early presenting aetiological factors play a pivotal role in skin integrity. For example, infantile eczema and atopic dermatitis may predispose towards inherently friable skin.^{6,7} Extreme infantile congenital skin disorders such as epidermolysis bullosa (EB) and skin ectodermal dysplasia/skin fragility syndrome (EDSFS) can severely affect skin integrity from an early age.

Epidermolysis bullosa is characterised by extremely fragile skin and recurrent blister formation ending in scars, as a result of minor mechanical friction or trauma.⁸

Skin ectodermal dysplasia/skin fragility syndrome is associated with severe cutaneous changes including skin fragility and blistering, with detachment of the upper epidermal layers as a result of skin disadhesion.⁹

Dermatological changes associated with diabetes are common, with many factors being responsible for the formation of skin abnormalities in almost one-third of diabetic patients. These include:

- Skin reactions to diabetic treatments
- Pathological skin involvement (eg, diabetic dermopathy and scleroderma)
- Infections.^{10,11}

Skin adjacent to chronic wounds resulting from venous insufficiency may be subject to additional pathologies. For example, patients may develop

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characteristic changes in the skin of the lower limb known as lipodermatosclerosis (LDS). This is generally associated with dry, flaky skin, induration and hyperpigmentation as a result of acute inflammation, and may also become ulcerated.^{12,13} Venous hypertension can lead to the trapping and activation of neutrophils and monocytes and the expression of pro-inflammatory cytokines. Subsequent endothelial cell damage in the epidermal microvasculature increases the susceptibility of peri-wound skin to physical injury in patients with LDS.¹⁴

Skin stripping: causes and pathologies

When adhesive tapes or dressings are removed from skin, varying amounts of superficial stratum corneum are removed with them. The repeated application and removal of adhesive tapes or dressings to and from the same site cause exogenous damage to the skin (skin stripping).¹⁵ Skin stripping may, in turn, lead to inflammatory skin reactions, oedema and soreness, all of which can have an adverse effect on skin barrier function.^{16,17}

Another consequence of skin stripping is pain.¹⁸ Dressing removal, which has the potential to cause trauma to delicate healing tissue in wounds and the surrounding skin, is considered one of the most painful wound-care interventions¹⁹ and can affect quality of life.²⁰ According to an international survey of wound-care practitioners, dried out dressings and adherent products were most likely to cause trauma and pain at dressing changes. Furthermore, there appeared to be a close association between dressings that caused wound trauma and those that caused pain.²¹

Damage to the stratum corneum and irritation due to skin stripping are subject to many variables; these may be patient-related (age, skin pathology) and adhesive-related (type and strength).^{17,22} The quantity and depth of corneocytes that are removed have a direct relationship with the degree of skin irritancy and adhesive applied. Repeated applications of adhesives enhance these detrimental effects.^{17,23}

The damage caused by skin stripping may be amplified in patients that have skin problems associated with ageing, disease (such as EB) or clinical interventions (such as radiation-induced skin damage).¹⁵

Comparisons of adhesive tapes and dressings in terms of their propensities to cause skin stripping

Different types of adhesives are used in tapes and wound dressings, including acrylics, hydrocolloids, polyurethanes, soft silicones and zinc oxide. The removal of acrylic, hydrocolloid, polyurethane and zinc-oxide adhesives can cause trauma (skin stripping) and pain^{16,24-26} as well as, in the case of hydro-

colloid and polyurethane adhesives, maceration.^{1,18} Soft silicone adhesives, on the other hand, provide an effective and safe level of adhesion to skin that, unlike some other adhesive types, such as acrylics, does not increase with time.¹

The literature search identified a number of studies involving either volunteers^{16,25,26} or patients with wounds/skin injuries,^{27,28} in which comparative data on the propensity for different adhesive tapes and dressings to cause skin stripping are presented.

Experimental models of normal human skin in healthy volunteers, although not totally indicative of clinical use, have addressed aspects of skin-surface adhesive interactions and demonstrated differences in the level of skin stripping related to various adhesive tapes and dressing adhesives and associated peel force.^{16,25,26}

In two of the volunteer studies^{25,26} and in a clinical study involving patients with venous ulcers discussed later in this article,²⁷ measurements of transepidermal water loss (TEWL) and skin surface hydration were undertaken.

An inverse relationship exists between TEWL and skin surface hydration (measured by cutaneous conductance), representing water barrier function and the stratum corneum hydration state respectively. These two parameters are good indicators of skin barrier stasis.

Water is normally retained in the stratum corneum, thus maintaining a viable skin-surface hydration state and barrier function, as well as helping to retain skin suppleness and flexibility.²⁹ Transepidermal water loss tends to be minimal in normal skin because of the water barrier function of the stratum corneum. Dry pathological skin, in comparison, demonstrates increased TEWL and low stratum corneum water content.³⁰

Peel force, skin stripping and cutaneous damage were assessed in a study involving 11 healthy volunteers who had daily applications of two ostomy adhesive strips (one with zinc oxide based adhesive (Smith & Nephew) and the other with a hydrocolloid-based adhesive (Assura, Coloplast), to the skin of their forearms for a four-week period.²⁶

The peel force of the zinc oxide adhesive increased significantly during the first two weeks, and was significantly higher ($p=0.007$) than that of the hydrocolloid adhesive for the rest of the study period. The zinc oxide adhesive was found to have a significantly higher TEWL than the hydrocolloid adhesive ($p<0.05$) in the first two weeks, after which no statistically significant difference in TEWL between the two adhesives was observed.

Throughout the study, the two adhesives were associated with significantly higher TEWL than the control sites ($p<0.05$). At the end of the study period, the mean water content of the skin treated with the zinc oxide adhesive was lower than that of the

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control sites, whereas the mean water content of the skin treated with the hydrocolloid adhesive was statistically higher ($p < 0.05$). Both adhesives caused skin tears at the edges of the treated areas.

The hydrocolloid adhesive was associated with TEWL and skin hydration levels that are consistent with those of non-pathological skin, although the hydrocolloid adhesive-treated skin exhibited erythema as a result of local irritation. In contrast, the zinc oxide adhesive induced pathophysiological cutaneous changes, including epidermal thickening and parakeratosis, which has similarities to skin diseases such as psoriasis and atopic dermatitis. Although this study related to ostomy adhesive strips, it is relevant to wound care as the adhesive systems used in the products evaluated are also used to facilitate dressing retention.

To quantify the peel force required to remove five different adhesive dressings and relate this to the amount of stratum corneum removed, an experimental study involving 20 healthy volunteers was undertaken.¹⁶ After staining the forearm skin of volunteers with a blue dye, three consecutive 24-hour applications of each dressing were made. Peel force measurements were undertaken at 24, 48 and 72 hours. After removal of the dressings, the amount of dye remaining on the skin was sampled and measured as a means of gauging skin damage (ie, on the assumption that the more dye was left on the skin, the less damage had been incurred, and vice versa).

Statistically significant differences were observed between some of the dressings, with a rank order from highest to lowest peel force as follows:

- Foam dressing with an acrylic adhesive (Allevyn Adhesive, Smith & Nephew)
- Foam dressing with a polyurethane adhesive (Tielle, Johnson & Johnson)
- Hydrocolloid dressing (Duoderm Extra Thin, ConvaTec)
- Foam dressing with Safetac soft silicone adhesive

(Mepilex Border, Mölnlycke)

- Foam dressing with hydrocolloid adhesive (Biatain Adhesive, Coloplast).

Differences between the dressings in terms of the level of damage to the stratum corneum were also observed (Fig 1). For most of the dressings evaluated, the amount of damage to the stratum corneum appeared to be related to the peel force — for example, the foam dressing with Safetac soft silicone adhesive was associated with a low peel force and a low percentage of damage, whereas a high peel force and a high percentage of damage were observed for the foam dressing with an acrylic adhesive.

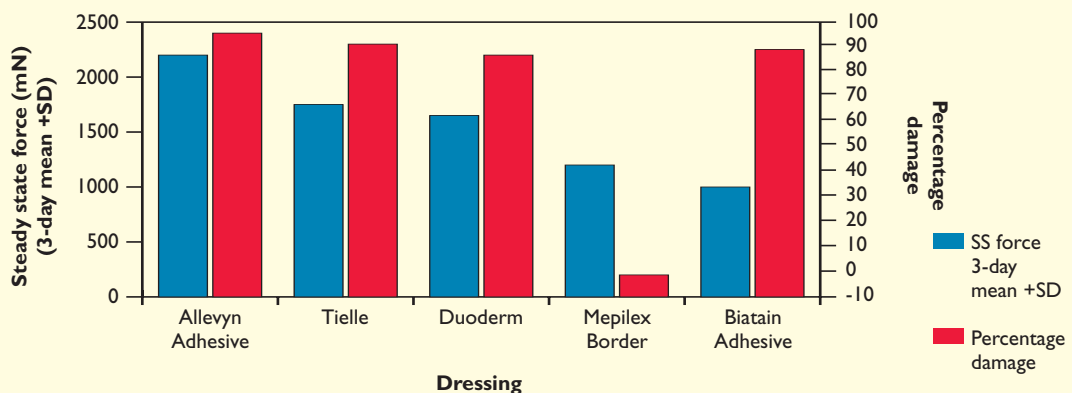
However, peel force did not always correlate with the degree of skin stripping observed — for example, the foam dressing with hydrocolloid adhesive was associated with a low peel force but a high percentage of damage, suggesting that factors other than peel force are involved in determining the level of skin stripping caused by adhesive dressings.

A more recent study involving 30 healthy volunteers set out to assess the effect of repeated application and removal of adhesive edges from six dressings on cutaneous irritancy and barrier function.²⁵ Six applications to the same test site were done over a 14-day period for the following dressings:

- Foam dressing with Safetac soft silicone technology (Mepilex Border Lite, Mölnlycke)
- Foam dressing with acrylic adhesive (Allevyn Adhesive, Smith & Nephew)
- Foam dressing with hydrocolloid adhesive (Biatain, Coloplast)
- Foam dressing with a polyurethane adhesive (Tielle Plus, Johnson & Johnson)
- Hydrocolloid dressing (Duoderm Extra Thin, ConvaTec)
- Hydrocolloid dressing (Comfeel Plus Transparent, Coloplast).

A cumulative irritancy score for each test site was determined by adding erythema scores (based on an

Fig 1. Comparison of adhesive dressings in terms of peel force and skin damage on removal¹



established ranking scale for cutaneous erythema) recorded at six time points during the study period. The skin barrier function of each site was assessed by measuring TEWL at the end of the study period.

The acrylic-, polyurethane-, and soft silicone-based adhesive foam dressings were associated with lower cumulative irritancy scores than both of the hydrocolloid dressings and the foam dressing utilising a hydrocolloid adhesive system (Fig 2). The acrylic-, polyurethane- and soft silicone-based adhesive foam dressings were associated with TEWL that was not significantly different from normal skin ($p < 0.05$), whereas the other dressings were associated with a significantly higher TEWL (Fig 3).

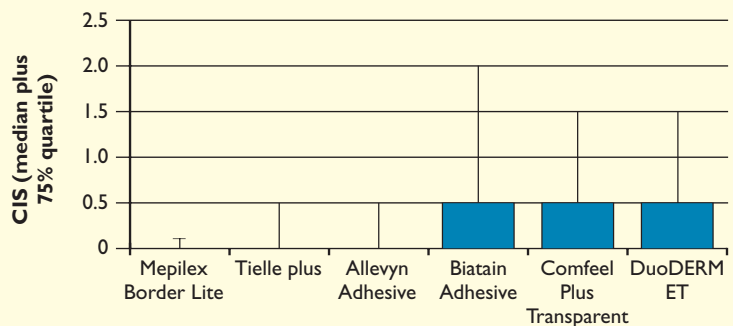
Reflecting on the findings of the studies described above, it is important to consider the relevance of volunteer studies to assessing the potential for adhesives to cause skin stripping in the clinical setting. The best indicator comes from the clinical study involving patients with venous leg ulcers²⁷ in which adhesive dressings were applied to both peri-wound skin and normal forearm skin. Interestingly, the TEWL measurements showed very similar responses on the peri-wound and forearm skin. However, as peri-wound skin is often more friable than normal healthy skin, it could be argued that the level of skin stripping observed in volunteer studies may not necessarily reflect the severity of skin stripping or the true difference between dressings in terms of their propensity to cause skin stripping in the clinical situation.

A clinical study involving 45 patients with venous leg ulcers was undertaken to assess the effects of repeated removal of adhesive dressings on the barrier function (measured by TEWL) and hydration (measured by electrical conductance) of peri-wound skin. Patients were randomised to treatment with one of four dressings:

- Foam dressing with hydrocolloid adhesive (Biatain, Coloplast)
- Foam dressing with polyurethane adhesive (Tielle, Johnson & Johnson)
- Hydrocolloid dressing (DuoDERM Extra Thin, ConvaTec)
- Foam dressing with Safetac soft silicone adhesive (Mepilex Border, Mölnlycke).

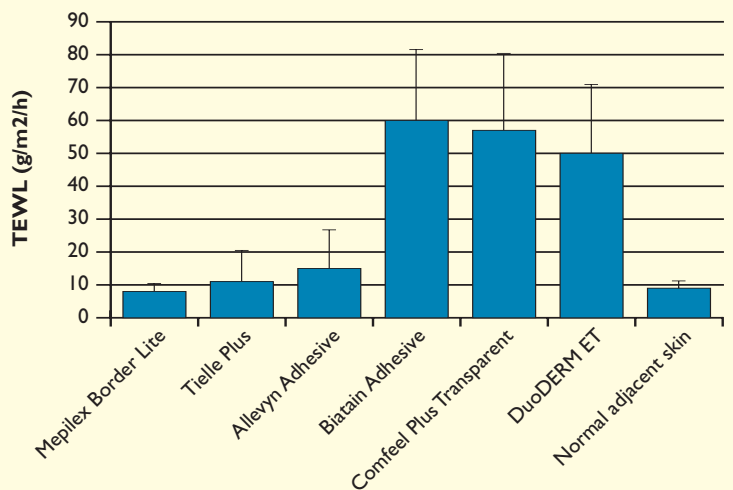
The peri-wound skin was treated for 14 days with patches of the dressings (replaced every two days); normal skin on the patients' forearms were treated identically as controls. The foam dressing with hydrocolloid adhesive and the hydrocolloid dressing were associated with increased TEWL and conductance (indicating that they induced major functional alterations of the stratum corneum), while the foam dressing with polyurethane adhesive and the foam dressing with Safetac soft silicone adhesive did not influence these parameters significantly, when compared with non-treated peri-wound skin

Fig 2. Comparison of adhesive dressings in terms of cumulative irritancy scores (CIS) associated with repeated application and removal²⁵



The following pairs are significantly different ($p < 0.05$): Mepilex Border Lite versus DuoDERM ET, Mepilex Border Lite versus Comfeel, Mepilex Border Lite versus Biatain, Tielle versus Biatain, and Allevyn versus Biatain

Fig 3. Comparison of adhesive dressings in terms of transepidermal water loss (TEWL) associated with repeated application and removal²⁵



(Fig 4).^{27,28}

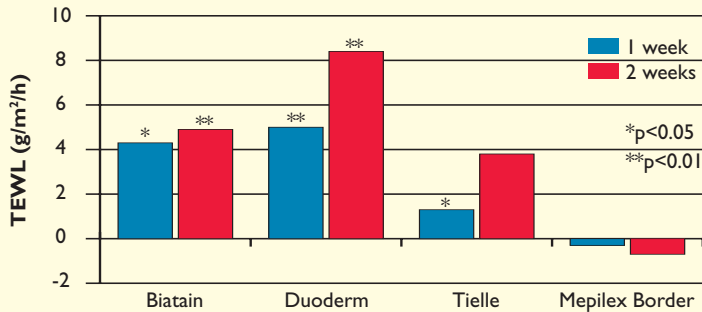
Avoiding skin stripping

Recommendations for preventing or minimising skin stripping include:

- Identifying at-risk patients (elderly and/or those with underlying pathologies)
- Closely monitoring patients for signs of skin stripping by performing regular pain assessments and examinations of peri-wound skin
- Choosing appropriate dressings that are designed to minimise skin stripping.

Adhesive-skin interactions are clearly key considerations in dressing choice, especially in relation to inherently friable and compromised skin as found in many and varied skin conditions. A fundamental requirement for appropriate dressing choice would

Fig 4. Comparison of adhesive dressings in terms of transepidermal water loss (TEWL) associated with repeated application and removal (peri-wound skin)²⁸



appear to be based on clinical requirements with close reference to dressing adhesive and skin adhesion. Ideally, the adhesive would be compatible with local skin conditions including age, anatomical site and pathological state, thus having the ability to reduce the incidence of skin stripping and related adverse cutaneous reactions such as erythema.

According to a consensus document issued by the World Union of Wound Healing Societies,²⁰ it is important that clinicians consider dressings that are known to be atraumatic on removal (ie, soft silicone). The atraumatic and virtually pain-free removal of soft silicone dressings has been demonstrated in a number of clinical studies involving adults, children and neonates with a variety of wound types (such as grafts, burns/scars, leg/foot ulcers, pressure ulcers, skin tears, amputation/surgical wounds, pressure ulcers, skin tears and amputations) as well as skin disorders (such as radiation-induced skin damage congenital skin disorders like EB),³¹ many of which are associated with friable and damaged skin. If soft silicone dressings have proved to be of benefit where the most fragile skin is encountered, then similarly advantageous outcomes can be expected in less challenging situations.

In relation to the management of damaged/friable skin and successful wound healing, several key issues need to be considered. Importantly, patient care plans frequently address issues related to the

protection of skin integrity at dressing change, including dressing choice, pain control, body fluids and patient comfort.³² Despite this, a 2001 survey of 1000 clinicians involved in wound care in the UK found that over one-third of respondents were unaware of products specifically designed to reduce cutaneous pain and trauma at dressing change.¹⁹ Dressing change represents a clinical challenge, particularly in patients with fragile skin that may be easily damaged and cause considerable pain.

A large number of advanced wound dressings aim to provide moist wound healing environments conducive to healing. However, the benefits of such an approach may be limited as a result of trauma and pain caused by the repeated application and removal of adhesive tapes and dressings. With this in mind, the selection and use of atraumatic wound dressings is extremely important. Unfortunately, appropriate care and intervention is dictated by the limitations imposed by human and financial resources. However, dressing choice based on initial low expenditure costs does not necessarily equate with best value for money when trying to achieve a successful patient outcome.³²

It is important, therefore, that the process of wound dressing selection is based on all aspects influencing the cost of treatment (ie, materials, labour and non-medical costs to society) and not solely on the unit costs of dressings.³³

Conclusion

Trauma following repeated removal of skin adhesive causes an erythematous reaction, which has an adverse effect on skin barrier function. Adhesive-skin interactions are clearly key components in dressing choice in modern wound care. The accurate assessment of a patient's needs, followed by application of the most appropriate dressing, should dominate dressing choice if unnecessary skin damage is to be avoided. Dressings utilising soft silicone adhesive technology have been shown to be effective in the treatment of a variety of wounds, most notably those associated with conditions which may predispose towards inherently friable skin. These dressings should be strongly considered in the treatment of wounds where care has to be exercised in avoiding trauma to the wound bed and peri-wound skin. ■

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