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Emollients: Function, Selection & Usage

Introduction

Research into the largest organ of the human body has significantly expanded knowledge in the last decade. Human skin is a complex organ with multiple functions, but its primary role is as a barrier preventing water loss from the body whilst limiting entry to unwanted external elements, such as chemicals, ultraviolet radiation, and microorganisms. Changes in the skin due to the environment or disease itself can result in dryness. Despite being given a trivial label, dry skin should be considered as a form of skin failure - a lapse in barrier function potentially leading to irritation, infection, inflammation and allergy.

Dry skin affecting the foot and lower leg is a common clinical issue, particularly for young and older patients. The use of emollients is a key part of restoring the barrier function and improving skin health. Although emollients are frequently recommended by podiatrists, knowledge of their function, selection and application is often limited. This CPU article will look at the problem of dry skin and how appropriate selection of emollients can make a significant difference to the improvement of skin health.

Epidermal Function

The human epidermis is a constantly renewing epithelial layer of specialist cells called keratinocytes. Epidermal cells are created by division of the cells along the basal layer. Over a period of around a month, these cells ascend through the strata of the epidermis (spinosum, granulosum and corneum) undergoing a complex process before gradually loosening and detaching as invisible scale. The maturation process is complex and sees a transformation from columnar, nucleated cells into dead, flattened keratinised cells (known as corneocytes) in the outermost layer. It is the stratum corneum that is key to the barrier function of the epidermis.

The gradual transformation of cells as they ascend the layers of the epidermis, from keratinocytes into corneocytes is termed differentiation. By the time the corneocyte has reached the stratum corneum, it has effectively died, losing its nucleus and organelles and is tightly wrapped in insoluble keratin as an envelope within its plasma membrane. Keratin is a highly hydrophilic molecule that can bind substantial amounts of water. Additionally, the corneocyte

contains proteins which assist by acting as a hydrophilic force, effectively making the cell function like a sponge retaining water. Distributed between the corneocytes is a hydrophobic lipid barrier consisting of fatty acids, cholesterol and ceramides. These are secreted by lamellar granules at the level of the stratum granulosum [1]. There are 9 known ceramides with varying chain lengths, which are considered vital for the skin barrier function, anchoring to the external surface of the corneocyte envelope.

In addition to the corneocytes and intercellular lipid layer, natural moisturising factors (NMF) consisting of water-soluble compounds (amino acids, pyrrolidone carboxylic acid [PCA], urea and lactate), add additional flexibility to the epidermis, along with a water binding capacity. Collectively, the NMF and intercellular lipids increase the skin's ability to hold water increasing elasticity and resilience. The combined effect is a stratum corneum that is strong and flexible, and being water bound within the corneocytes maintains turgidity, forming tight cell-to-cell apposition.. Endogenous antibiotics produced within these cells (antimicrobial peptides) provide antimicrobial protection against bacteria, viruses and fungi. Gradual desquamation (around 40mg a day) of the cells of the stratum corneum and replenishment of the lost cells occurs in a balanced manner as new cells ascend the epidermis, ensuring a consistent thickness is maintained.

Filaggrin, a genetically coded macromolecule, is the key source of NMF. Extruded from keratohyalin granules in the stratum granulosum, enzymatic degradation of filaggrin liberates antimicrobial peptides and NMF into the epidermis increasing its water content [2]. Structurally, it also leads to flattening of the epidermal cells. Mutations to the filaggrin gene are associated with the development of dry skin conditions, such as atopic eczema and ichthyosis (see Clinical Application 2). In addition, enzymatic degradation of filaggrin is dependent on water levels within the skin and the relative humidity.

The skin surface is maintained at a pH of around 5.5, often termed the "acid mantle". The function of this is two-fold – firstly to suppress growth of pathological bacteria and secondly to regulate the enzymatic processes involved in desquamation [3]. Increasing skin pH leads to epidermal thinning through increased protease enzyme activity (see Clinical Application 1) and an imbalance of the skin natural flora, favouring the growth of more pathogenic bacteria such as staphylococcus aureus.

Key Point: An increase in skin pH can lead to thinning and skin barrier failure.

Clinical Application 1

Soaps generally have a pH of 8 – 9, higher than skin, and which is within the alkaline range. The temporary effect of soap use raises skin pH, leading to a disturbance in the acid mantle. Whilst most skin can quickly recover and restore its natural acidic pH, cumulative use of soap can lead to irritation and drying of the epidermis, particularly in younger and older patients. A chronically elevated skin pH can lead to epidermal thinning as there is increased protease enzymatic activity leading to accelerated desquamation.

Avoidance of soaps can be helpful, but many non-alkaline skin cleansers contain synthetic surfactants, such as sodium lauryl sulphate and sodium laureth sulphate (SLS) which have been shown to affect epidermal function by binding to keratin and raising the pH of the epidermis [4]. Moreover, repeated application can lead to rapid depletion of the intercellular lipids and destruction of corneocytes causing leeching of the NMFs from within their matrix. Consequently, the use of SLS-containing emollients, such as aqueous cream, is not recommended [5].

Key Point: As a general rule, if a skin cleanser such as a shower gel or synthetic soap foams under running water, it is likely to be harmful by stripping the natural lipids from the skin. The addition of fragrances or perfumes can also compound the problem of skin irritation.

Clinical Application 2

Ichthyosis is a common, inheritable group of skin conditions that present with dry skin as the central feature (Figure 1). There are many forms of the disease but the most common is ichthyosis vulgaris, which accounts for 95% of cases of ichthyosis and affects around 1:250 people. This presents as dry skin affecting the trunk, scalp and limbs; the feet may also be prone to fissuring. The disease is caused by a mutation in the gene encoding filaggrin located on chromosome 1, resulting in a loss of function. Such a change to the gene is also a major predisposing factor for atopic dermatitis as many patients may have both conditions. Mutation to the gene can lead to an absolute or relative deficiency of filaggrin which causes skin barrier disruption, fragility and increased permeability. Consequently, patients may be more prone to irritant and allergic contact dermatitis. Histology of the epidermis demonstrates an absent or reduced stratum granulosum depleted of keratohyalin granules [6]. Emollients are the mainstay of treatment for the condition, with urea being particularly effective.

Figure 1: Ichthyosis affecting the feet

What causes dry skin?

Although dry skin is clinically straightforward to recognise, there is no standard definition of what it is. Dryness (xerosis) is loss of water within the epidermis, characterised by a visible scaliness with a reduction in skin elasticity and flexibility [7], frequently accompanied by itching or redness. It has a wide spectrum of effect ranging from mild scaling to severe skin disease. The condition affects people of all ages, particularly those with dermatoses, such as atopic eczema, ichthyosis and asteotic eczema. In a study of 48 000 working adults, 29.4% were diagnosed with a dry skin condition. The study highlighted how the prevalence of dry skin increases with age [8]. Other work has estimated rates of xerosis as high as 85% in older adults [9]. A recent systematic review has highlighted how stress can affect epidermal barrier function. Increasing psychological stress levels can lead to increased production of stress hormones. These can lead to barrier dysfunction by decreasing epidermal lipid and structural protein production along with increased transepidermal water loss [10].

Key Point: Around 29% of working age adults have clinically dry skin

Causes of Dryness

The causes of dry skin are multifactorial but can be loosely termed as physiological and pathological: those due to behavioural and environmental factors (physiological); those due to specific disease processes (pathological) (see Table 1). In many cases, dry skin is a result of behavioural and physiological causes, such as overbathing and excessive use of cleaning products on the skin which contain surface cleansers such as sodium lauryl sulphate (SLS) which rapidly strip natural moisturising factors from the skin. Dry skin is more prevalent in the older patient as skin turnover times are prolonged and NMF production is reduced. Moreover, seasonal changes can make a difference with alterations in the ambient temperature and humidity levels (see Case Study 1, page 4). Sun exposure can lead to excessive amounts of UV light reaching the skin which can reduce the functionality of lipids and protein in the stratum corneum, leading to dryness within the skin. Structural changes occur in skin with age; within the epidermis cell numbers decrease along with the epidermal turnover rate and lipid ceramide production. Xerosis becomes more prevalent with ageing, particularly on the limbs, as barrier function reduces often as a combination of environmental and pathological causes [11].

Key Point: The limbs are particularly affected by dry skin with ageing.

In addition, pharmacotherapies such as statins, diuretics and antiandrogen medications can reduce skin NMFs.

Key Point: Most dry skin is due to behavioural and environmental factors such as overbathing and the use of synthetic skin cleansers.

Table 1: Causes of Dry Skin

Behavioural / Physiological	Environmental	Pathological
Young or old age Menopause Overbathing/wet work Bathing/Showering in hot water Excessive sun exposure Soaps, bubble baths and shower gels Insufficient rinsing of skin	Low ambient temperature Dry indoor heating Low humidity Air conditioning Sun exposure	Skin disease Iron Deficiency anaemia Lack of Vitamins and Zn, Mg Renal failure Thyroid disease Diabetes mellitus Anorexia Cancer Drugs: statins, diuretics, cytotoxics, alcohol

Effects of Emollients

The word emollient derives from the Latin emollire "to make soft or soften". The term 'emollient' is often used synonymously with moisturiser. Emollients are probably one of the most recommended products in podiatry practice, however knowledge of their constituents and action on the skin is often overlooked. There is a vast array of emollient products on the market with a bewildering range of ingredients. One study, by Amakye and colleagues, reported over 120 emollient products in the UK market [13]. Despite this, they all serve a common function, to trap, concentrate or replace water within the epidermis. Water replenishment softens the skin, reduces scale, and improves skin barrier function by causing cells to take up water, swell and improve cell apposition restoring the natural skin barrier. The majority of the available emollients are creams, ointments, gels and lotions which are lipid-based, balanced with varying degrees of water which affects consistency ranging from greasy to light. High lipid content preparations tend to be more ointment-based and therefore heavier, more occlusive and harder to spread. Cosmetically, they are less well tolerated than lighter preparations, such as creams and gels which have a lower lipid content. Although creams and gels are less greasy, easier to spread and more acceptable to most, their moisturising capacity is less.

Case Study

A 79-year-old male presents with an area of erythema and scaling on the dorsa of both feet which has been present for a few weeks. The patient reports slight itching and other similar patches occurring around the ankle area (Figures 2 and 3). Medically, he takes a simvastatin and amlodipine for hypertension but is overwise well. Diagnosis: Asteotic eczema. The condition is common in older adults particularly as winter approaches. The temperature and ambient humidity drop leading to the development of scaly patches on the tops of the feet and around the ankles. For the elderly, this is normally during the autumn when the central heating goes on leading to dry, warm air which can provoke the condition. Statins are a medication known to cause dry skin and increase the risk of developing eczema [12].

Management requires the regular application of an emollient (Figure 4). Products containing humectants are particularly good, such as a urea-based product applied twice daily. Patients should also be advised to reduce their bathing frequency and/or duration, along with cooler water temperatures as appropriate. The legs should be thoroughly rinsed to remove any residual wash products which may remain on the skin and may have run down the legs during showering. Wool socks should be avoided as fibres can irritate the skin.

Figure 2: Asteotic eczema on the dorsum of the foot

Figure 3: Asteotic eczema on the leg

Figure 4: Asteotic eczema after emollient therapy

Key point: There is no evidence to suggest any one emollient preparation is superior to another. Patient choice is key.

The are many benefits to the use of emollients. Application may increase water content in the epidermis in two ways. Firstly, by increasing the water holding capacity of the stratum corneum by the application of hydroscopic (hydrophillic) chemicals known as humectants. These mimic the NMFs within the skin cells acting like sponges. The second method is by the application of a lipid film (lipophilic) effectively trapping water in the skin and preventing water loss.

Well moisturised skin looks and feels softer, smooth and more resilient, reducing the risk of fissures. Scaling is also diminished. In addition, well hydrated skin is less likely to itch – a common problem which drives further skin irritation and inflammation. Finally, for those using steroid preparations, concurrent emollient use has been shown to enhance the effectiveness of topical steroids.

Within the UK, emollient formularies are available within most NHS commissioning groups and health boards. A detailed study by Ridd et al. of emollients highlighted many unique formularies are available nationally with little consistency between them and often recommending specific emollient products. Evaluation of the reasoning for recommendations was, in the majority, based on cost and a suggestion that all emollients are therapeutically equivalent for which there is no evidence [14]. In addition, formularies varied in their level of detail and some were contradictory in their advice [13].

Which is the Best Emollient?

Available evidence suggests that emollients can improve the severity of dry skin conditions, but research into the comparative effectiveness of different products is lacking. A Cochrane Review [15] considered 77 studies and concluded there was no evidence to suggest any one moisturiser was better than any other. However, it was found that emollients were more effective than no emollients for dry skin and eczema, through reducing the severity of dry skin conditions, helping to reduce the need for topical steroid application and reducing the number of skin flare ups.

Traditionally, dermatologists have recommended that very dry skin conditions are best managed by a greasier type of emollient, such as an ointment, but evidence to support this approach is lacking and patient preference is key to ensuring an emollient is used. Each person using an emollient may have differing sensory perception as to what feels right for their skin. This may be based on the time it takes a cream to absorb, greasiness, tackiness, end feel, or odour, for example.

A study in the USA by XU et al. collated 109 000 user reviews of the top 100 consumer moisturisers sold at 3 major retailers. According to patients, the most popular vehicles were lotions (59%), followed by creams (13%), oils (12%) with ointments only preferred by 2% [16]. These results were reflected in a UK study surveying the parents of children with eczema. Parent satisfaction was highest with lotions and gels, less so with creams, whilst ointments were the least acceptable [17]. Moreover, in this study, the results showed no difference in symptoms of eczema after 16 weeks of application whether a lotion, gel, cream or ointment was used.

Risks and Emollients

Emollients have many benefits, but their users should be advised of a potential fire risk. Whilst emollients themselves are not spontaneously flammable (on the skin or in their containers), the risk of flammability increases when they rub off the skin into clothing, bandages, bedding, and furniture. Whilst paraffin-based products were initially classed as a risk, it has since been discovered that all emollients dried into textiles and clothing can act as an ignition accelerant and prolong burn times even after washing [18]. Further information about the risks can be found here [https://www.gov.uk/guidance/safe-use-of-emollient-skin-creams-to-treat-dry-skin-conditions].

Key Point: Patients should be advised of the fire risks associated with emollient use.

Contamination of Emollient Products

Contamination of emollients with microbes is a well-recognised issue, particularly if they are water based. Emollients can become contaminated with bacteria and fungi – this is unlikely to occur during the production process but more commonly happens once the product has been opened for use. The presence of microbes can alter the pH and thereby breakdown the formulation producing discolouration and malodour. In addition, if these organisms are applied to the skin, infection may result. A study by Carr et al. reviewed 73 emollient products used by patients. Each were swabbed and the results showed 53% were contaminated with bacteria, 25% were Staphylococcus aureus and 11% were gram negative organisms [19]. The use of pumps rather than traditional pots has the advantage of a one-way valve system that prevents microbes from contaminating the emollient reservoir. If pots are to be used, patients should be advised never to put their fingers into the product

Figure 5: The use of a clean spatula reduces emollient contamination with bacteria

and to use a clean spatula instead to reduce the chances of microbes being introduced into the product (Figure 5).

Key Point: Contamination of emollients is a common issue. The use of pumps rather than pots can reduce the risk.

To reduce the risks of contamination, preservatives are frequently added to an emollient formulation (see Table 2). Like other ingredients within an emollient formulation, occasionally preservatives can be responsible for adverse reactions in patients. Where there is concern and reactions have occurred when using other emollient products, patients should be advised to apply the emollient to a small area first before widespread application [20].

Adverse reactions to emollients are not common. In many cases this is a result of irritancy rather than true allergy. Irritancy can arise rapidly as erythema and itching on sensitive skin without prior exposure to the irritant. A true allergic reaction generally develops after a period of time from initial exposure. Patients with a history of skin disease, particularly atopic eczema, should be treated cautiously as this group has a high rate of irritancy and allergy. If there is doubt as to the suitability of a new product applying a small amount to a test area of the skin for 48 hours can be useful to anticipate any potential issues.

Key Point: Where sensitivity to an ingredient in an emollient is a concern, any new product should be tested for 48 hours on the skin before general application.

Table 2: Common Preservatives Found in Emollients
Parabens (including Methyl, Ethyl, Propyl, Iso forms)
Phenoxyethanol
Methylchloroisothiazolinone/Methylisothiazolinone
Benzyl Alcohol
Sodium Benzoate/Benzoic acid
Sorbic Acid
Chlorocresol

Humectants

Humectants are water absorbing (hygroscopic) substances commonly added as emollients for their known ability to draw and bind water within the epidermis. Urea [NH_2CONH_2] is a natural by-product of protein metabolism created in the liver by combining carbon dioxide [CO_2] and ammonia [NH_3]. It is pH neutral and highly water soluble. In the skin, it is produced by the breakdown of filaggrin and is transported into keratinocytes. As a humectant, it draws water into the cells through water channels (sometimes called aquaporins) causing the cell to swell and maintain apposition, improving barrier function. The value of urea is not only its humectant properties but other identified benefits [21]:

- Increased production of antimicrobial peptides in the epidermis
- Reduction of trans-epidermal water loss
- Antipruritic
- Promotion of lipid producing enzymes
- Epidermal thinning (reduction of hyperkeratosis) without loss of function

A wide range of emollient products exist containing various concentrations of urea, from 5%-40%. From a scientific viewpoint, the optimum urea concentration in any product remains unproven with many of the aforementioned benefits being observed in urea concentrations of 10% or less [22]. A recent study comparing the effects of placebo, 5% and 20% urea creams on the plantar surface showed while placebo cream had little effect on plantar skin hydration, there were no significant differences in hydration levels on the soles when comparing 5% and 20% urea creams [23]. At higher concentrations, above 25%, urea becomes less hydrating and more keratolytic and therefore should be used with caution in some patients [24]. As a natural chemical produced in the skin, it is generally well tolerated. Because of its properties, urea is commonly formulated into foot and leg emollients.

Other humectants include amino acids, retinol (vitamin A), tocopheryl acetate (vitamin E), propylene glycol, lactic acid, polyethylene glycol (PEG) and glycerol. Glycerol is a common additive in preparations as it can absorb many times its weight in water and regulates skin desquamation. Oats are incorporated into some emollients as a colloidal preparation (e.g. Aproderm Colloidal® & Aveeno®). The starch and beta-glucans have strong water binding properties, along with avenanthramides which improve skin barrier repair and reduce itching.

Key Point: Urea is a useful additive to emollients for its multiple properties in improving the skin barrier.

Selection of Emollients

As national consensus guidelines [25] recommend, emollient selection is based primarily on the patient's choice and what they will use. This is based on its feel, odour, application, absorbency and in some cases, price. Patients should be encouraged to try a range of preparations to discover what feels right for them. To assist, samples can be obtained, usually at no cost, from the manufacturers and given to the patient to try. The main types of emollients available are lotions, creams, gels, ointments, sprays and soap substitutes. Aproderm® offer a starter pack of four different types of emollient (colloidal oatmeal, cream, gel and ointment) for the price of one prescription. Patients can then try each and decide which is most suitable for them.

Most emollients are considered bland with no active ingredients. Products containing fragrances are best avoided to reduce the risk of irritation. A few proprietary emollients have additional additives, such as antibacterials (chlorhexidine or benzalkonium chloride), anti-pruritics (lauromacrogols), anti-inflammatories (nicotinamide) and humectants/keratolytics (urea, lactic acid or salicylic acid). Products containing antibacterials should not be used as a "leave on" product to reduce irritation and sensitisation.

Once the patient has identified or chosen a product which they are happy to use larger quantities may be obtained from the pharmacy or, in some cases, by prescription from the general practitioner. Most preparations, except for ointments, are available as pump dispensers (usually around 500g). These offer greatest value in terms of quantity but also reduce waste and eliminate the problem of contamination through the delivery system. National guidelines [20] advise that adequate quantities should be prescribed. As a guide, around 4g–8g should be advised as a daily quantity for those with dry skin on the feet.

For patients, it can be helpful to discuss how an emollient should be used together with some simple

Product	Notes
Simple Emollients	
Aproderm® cream or gel	
Aqueous cream®	May contain Sodium lauryl sulphate – use only as wash product
Cetraben®	
Diprobase®	
Doublebase gel®	
E45®	
Epaderm®	
QV cream®	
Unguentum M®	
ZeroAQS ®	
Emollients with additional properties	
Urea based products	
Allpresan® Diabetic Foam Basic	5% urea
Allpresan® Diabetic Foam Intensive	10% urea
Balneum® intensiv cream	5% urea and ceramide
CCS® Foot Care Cream	10% urea
CCS® Heel Balm	25% urea
Dermatonics Once heel balm®	25% urea
Simply Feet Foot Cream	10% urea
Simply Feet Heel Balm	25% urea
Ureka® 10% Urea Cream	10% urea
Ureka® 25% Urea foot care Cream	10% urea
Antiseptic containing emollients	
Dermol® range	Benzalkalonium chloride / Chlorhexidine
Oilatum Antiseptic Bath Emollient®	Benzalkonium chloride
Other emollients with additional properties	
Adex gel®	Nicotinamide 4% (anti-inflammatory)
Aproderm Colloidal®	Colloidal oatmeal (anti-inflammatory)
Balneum®	Ceramide containing emollient
Hydromol® cream	Contains the NMF PCA

Table 3: Examples of commonly used emollients

advice. Firstly, for maximal effect, emollients are best applied when the skin is warm and slightly damp – for example just after a shower or bathing. Skin is best dried with a towel by dabbing rather than rubbing as this can irritate sensitive skin. Application of the emollient onto the legs should be in a downward direction along the direction of hair growth as this prevents clogging of hair follicles. Any open areas of skin should be avoided to prevent the development of irritation or the risk of contact dermatitis. Patients with dry skin should be advised to avoid soaps and synthetic cleansers (those which foam under running water) which can be replaced with a soap substitute (emollient wash or shower product). Most branded emollients have these within their product ranges.

Clinical Application 3

For patients with excessive dryness and hyperkeratosis of the foot that requires intense moisturisation, a wet wrap technique [26] is a useful means to improve skin quality. The procedure is as follows:

1. After a bath or shower, in the evening, a generous amount of 25% urea is applied to the feet, heels and plantar surface.
2. A clean, DAMP sock is then applied to both feet.
3. A clean, DRY sock is then applied over the top.
4. This is left on overnight before removing the sock(s) in the morning and washing their feet as normal.

This is normally conducted 3 times a week and reviewed at 4-week intervals by the podiatrist to assess progress. This can be continued for a number of months until the problem is brought under control.

Conclusion

Dry skin is a common clinical problem, with a prevalence that increases with age. Dry skin is not only an aesthetic problem, but for the foot and lower limb can lead to an increased risk of infection, irritancy, and allergy. Alongside emollient therapy, recognition of the underlying causes and the provision of patient education are important aspects of management. Selection of the appropriate product can increase patient concordance and improve skin condition. ▪

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