The effect of diabetes on the skin before and after ulceration

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Article points

1. People with diabetes are more prone to skin injury and ulceration.
2. Diabetes impairs the skin's ability to heal.
3. Scar tissue is not as strong as the tissue was before injury.
4. Skin should be kept in the best condition possible to prevent re-ulceration.

Key words

- Healing
- Re-ulceration
- Scar tissue
- Skin

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Diabetes affects the skin in many different ways at a microcirculatory level, making it more prone to injury and ulceration. These changes not only have an impact on healing but also on the resulting scar tissue, which is not as strong as the skin was prior to injury. Amputation rates are at their highest ever in England, with re-ulceration rates reported to be as high as 70% after 5 years. This article looks at the changes that occur in the skin of patients with diabetes and the importance of skin care before and after ulceration.

A history of ulceration is considered to be a significant risk factor for ulceration, and as such people with diabetes are classed as high risk if they have a history of ulceration on their feet (National Institute for Health and Care Excellence, 2015). Eighty-five per cent of amputations are preceded by ulcers (International Diabetes Federation, '*Diabetes and the Foot*'), therefore the prevention of re-ulceration is an important consideration in reducing amputation rates, which are reported to be at their highest rate ever in England (Kong and Gregory, 2016). Varying rates of re-ulceration have been reported in the literature, but the proportion of patients in this group increases over time; Miller et al (2014) reported 34% re-ulceration at 1 year, 61% at 3 years and 70% at 5 years.

There are different reasons that effect skin as to whether patients develop ulcers, including their vascular status, nutritional status and compliance with preventative therapies such as custom-made shoes/insoles (Miller et al, 2014). Despite these interventions, one study has reported a 30% re-ulceration rate over a 2-year period during which patients received regular podiatric review (Westphal et al, 2011). Do we therefore need to consider skin changes after healing and the effect of diabetes on the microcirculatory changes in the skin as factors contributing to re-ulceration?

The skin

The skin is the largest organ of the body. When intact it acts as a barrier, preventing substances entering the body, as well as preventing moisture loss. It helps to regulate temperature and provides sensory information, for example, pain, touch and temperature. It has three layers: the epidermis, the dermis and a fat (subcutaneous) layer (see *Figure 1*). The epidermis is the thin outer layer, known as the stratum corneum, which is thicker on the planter aspect of the foot and is relatively waterproof. When undamaged, the epidermis prevents bacteria and other substances from entering the body. The dermis contains the nerve endings, sweat glands, oil (sebaceous) glands, hair follicles and blood vessels. It consists of a thick layer of fibrous and elastic tissue, giving the skin its flexibility and strength. Below the dermis lies a layer of fat that helps insulate the body from heat and cold, providing protective padding, and serving as an energy storage area (Health and Safety Executive, 2016).

The healing process

When the skin is damaged a complex healing process takes place that can be divided into four phases, see *Box 1*. The final stage of healing, maturation, lasts from 21 days to 2 years. During this process, epithelial cells reduce the size of the wound. This is followed by re-organisation of the collagen by macophages to form a scar (Brown,

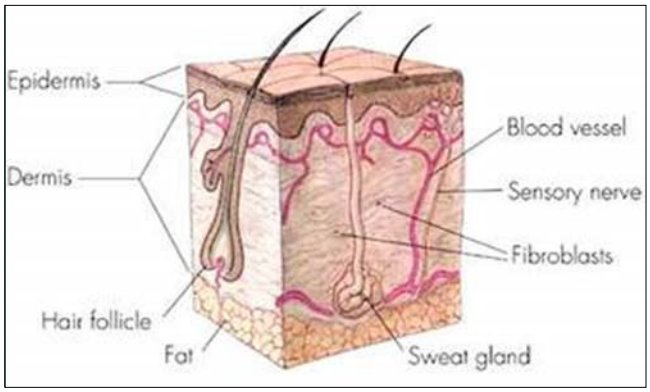

Figure 1. Cross-section through the skin.

Page points

1. Skin conditions such as infection, xerosis and psoriasis, are common in people with diabetes.
2. Regular moisturising of dry skin is recommended as part of a routine foot care regimen.
3. Scar tissue is not as strong as the original un-injured tissue and so is at increased risk of damage.

2015). In healthy subjects the resulting scar tissue formed after injury has approximately 80% of the tensile strength of normal skin (Ousey, 2009). Many factors play a role in how closely the healed skin resembles the original un-injured tissue, including the size, depth and location of the wound, as well as the nutritional status and overall health of the patient (Teller and White, 2009).

The diabetic effect

Diabetes can affect the skin in different ways. Autonomic neuropathy is a common complication of diabetes leading to dry skin, loss of sweating and the subsequent development of fissures and cracks that break the skin barrier, allowing microorganisms to enter (Vinik et al, 2003). It has also been demonstrated that there is a reduced oxygen supply within the tissues of people with diabetes, which is accentuated in the presence of neuropathy (Greenman et al, 2005). Other skin conditions are also commonly seen in people with diabetes, the prevalences of which are reported to be between 30% and 91.2% (Demiresren et al, 2013). The most frequently reported skin condition in diabetic patients is cutaneous infection (mainly fungal), followed by xerosis (dry skin) and inflammatory skin diseases such as psoriasis (*Figure 2*). These conditions are more common in diabetic patients with nephropathy than in those without nephropathy and those with diabetes who have a HbA_{1c} of >8 are at the greatest risk (Demiresren et al, 2013).

Box 1. The wound healing process.

- **Vascular response (haemostasis):** injured vessels constrict, a clot forms consisting of a fibrin mesh that forms a scab, and vasodilation of the vessels commences.
- **Inflammation:** occurs in acute wounds 3–5 days after injury and is prolonged in chronic wounds.
- **Proliferation:** collagen fibres form to replace lost tissue.
- **Maturation:** in healthy individuals this stage commences 21 days after injury. Scaring develops, which is avascular and contains no hair, sebaceous or sweat glands.

Vascular endothelial cells line the entire circulatory system, from the heart to capillaries. These cells are important for vascular biology and become impaired not only with age but also as a result of hyperglycaemia, which results in the impairment of blood flow to the tissues (Petrofosky, 2011). When pressure is applied to healthy skin, the affected tissues can become hypoxic; once the pressure is released there is a reactive hyperaemia (increase in blood flow) to oxygenate tissues. Vascular endothelial dysfunction can diminish this response. It has also been demonstrated that while standing, the average person still has circulation in the skin but in people with diabetes (even those with normal weight) there is occlusion to the skin (McLellan et al, 2009). This occlusion, together with reduced or no post-occlusive hyperaemia, may be the reason that feet are so susceptible to wounds and skin injury, particularly in people with type 2 diabetes (Petrofsky, 2011).

Emollients

Regular moisturising of dry skin is recommended as part of a routine foot care regimen to maintain healthy skin that is less likely to break down and ulcerate. What is not clear is which emollient to use. There is little evidence available as to the most effective emollient, not only for the general population, but also for people with diabetes. A moisturiser that the patient is willing or happy to use that is supported by the available evidence is preferable. The clinician should also check that the patient likes the smell, texture and absorption of the cream before recommending/prescribing one. There is some evidence that high-concentration

Figure 2. Psoriasis is one of the most common skin conditions experienced by people with diabetes.

urea-based emollients, such as Dermatonics Once Heel Balm (Young et al, 2014), are beneficial, and these have been shown to improve dryness on the feet of people with diabetes (Bristow, 2013).

For twice-a-day application, it is recommended that emollient is applied before getting into bed. Covering the foot with a damp under sock and then a dry over sock may enhance the effect of the emollient (Bristow, 2013). For once-a-day application, the cream should form part of a patients daily regime of washing; drying and checking their feet thoroughly. A pump dispenser is considered by some clinicians a more user-friendly way of delivering the right amount of emollient than a tub and also decreases the risk of contamination (Carr et al, 2008), although tubes are also commonly used.

Silicones

Once skin has healed, silicone gel has proven to be effective in scar tissue management on non weight-bearing areas; however there is little evidence to support its use on weight bearing areas (Westphal et al, 2011). A case study demonstrated that silicone gel may be useful in protecting newly-healed skin during the maturation process (Bristow, 2013). A patient with type 2 diabetes who suffered from psoriasis had developed ulceration and subsequent osteomyelitis at the base of the fifth metatarsal head, which had healed well with the use of a removable cast device. Once back in his bespoke shoes with total contact insole, however, the skin re-ulcerated (*Figure 3*). Silicone sheeting was used to protect the area once epithelisation was achieved and for 8 weeks afterwards. There was no further ulceration during the time the silicone sheeting used (*Figure 4*). This suggests that the silicone provided some protection to the newly-healed skin for this patient during the early stages of the maturation process (Weaving, 2014).

However, a pilot study of 30 patients concluded that silicone gel sheeting did not reduce the risk of ulceration in diabetic patients (Westphal, 2011).

Discussion

There are many factors affecting a person's skin when they have diabetes. These factors can lead to ulceration and contribute to delayed healing, with many factors still being present once the wound has healed. Poor control of diabetes has been shown to affect the microcirculation, with poor oxygen supply, occlusion in the skin during weight-bearing, changes to the vascular endothelial cells, dry skin and reduction in elasticity all putting the skin at greater risk of injury. This is further complicated by the reduced strength of the scar tissue that forms after the ulcer has healed.

Eighty per cent of ulcers are caused by some sort of trauma, and they are therefore considered to be preventable (Healy et al, 2013). While custom-made footwear is used to prevent re-ulceration, it appears to be most effective for those with foot deformity (Reiber et al, 2002). Not every insole or shoe is a perfect fit to each patient's foot (Miller et al, 2014). It is therefore important that the skin on the foot is kept in the best condition it can be to cope with the stresses placed upon it, whether it is from shoe wear or simple day-to-day weight-bearing activities.

Conclusion

There is little evidence on how best to look after the skin of people with diabetes. From the available evidence, the healing of a diabetic foot ulcer should not be considered the end result of a

patient's journey, but the beginning of a process to remain healed. We want patients to be active and keep mobile to help with their overall health and wellbeing, however, the impact of diabetes on their skin makes them vulnerable to skin breakdown, particularly where there is scar tissue from previous ulceration. Further research is required on the most-effective way to care for the skin of people with diabetes not just when dry, but also post-healing during the maturation process when the stresses and strains of simple weightbearing could lead to re-ulceration and, subsequently, potential loss of a limb. ■

Bristow I (2013) Emollients in the care of the diabetic foot. *The Diabetic Foot Journal* **16**: 61–6

Brown A (2015) Wound management 1: Phases of the wound healing process. *Nursing Times* **111**: 12–3. Available at: www.nursingtimes.net/download?ac=3000502 (accessed 02.09.2016)

Carr J, Akram M, Sultan A et al (2008) Contamination of emollient creams and ointments with Staphylococcus aureus in children with atopic dermatitis. *Dermatitis* **19**: 282

Demirseren DD, Emre S, Akoglu G et al (2014) Relationship between skin diseases and extracutaneous complications of diabetes mellitus: clinical analysis of 750 patients. *Am J Dermatol* **15**: 65–70

Greenman RL, Panasyuk S, Wang et al (2005) Early changes in the microcirculation and muscle metabolism of the diabetic foot. *Lancet* **366**: 1711–5

Healy A, Naemi R, Chockalingam N (2013) The effectiveness of footwear as an intervention to prevent or to reduce biomechanical risk factors associated with diabetic foot ulceration: a systematic review. *J Diabetes Complications* **27**: 391–400

Health and Safety Executive (2016) Structure and functions of the skin. Available at: www.hse.gov.uk/skin/professional/causes/structure.htm (accessed 02.09.2016)

International Diabetes Federation. *Diabetes and the Foot*. Available at: http://bit.ly/2cUTPJB (accessed 13.09.2016)

Kong M-F, Gregory R (2016) Preventing foot complications in diabetes: the St Vincent Declaration 26 years on. *Practical Diabetes* **33**: 154–7

McLellan K, Petrofsky JS, Zimmerman et al (2009) The influence of environmental temperature on the response of the skin to local pressure: the impact of aging and diabetes. *Diabetes Technol Ther* **11**: 791–8

Miller JD, Salloum M, Button A et al (2014) How can I maintain my patient with diabetes and history of foot ulcer in remission? *The International Journal of Lower Extremity Wounds* **13**: 371–7

National Institute for Health and Care Excellence (2015) *NICE guideline 19. Diabetic foot problems: prevention and management*. www.nice.org.uk/guidance/ng19?unlid=73767733201629145251 (02.09.2016)

Ousey K (2009) Chronic wounds – an overview. *Journal of Community Nursing* **21**: 4–9

Petrofsky JS (2011) The effect of type-2-diabetes-related vascular endothelial dysfunction on skin physiology and activities of daily living. *J Diabetes Sci Technol* **5**: 657–67

Reiber GE, Smith DG, Wallace C et al (2002) Effect of therapeutic footwear on foot reulceration in patients with diabetes. A randomised controlled trial. *JAMA* **287**: 2552–8

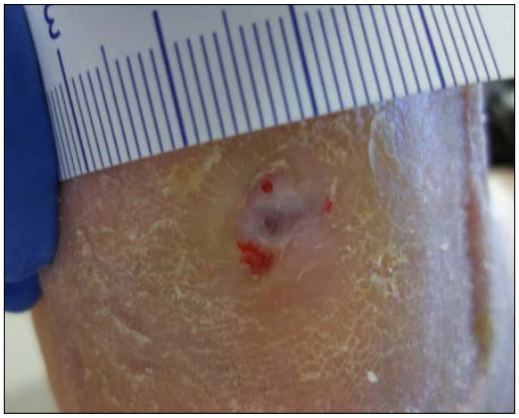

Figure 3. A patient with type 2 diabetes and psoriasis experienced re-ulceration after changing from a removable cast device back to his bespoke shoes.

Figure 4. Continuing to use silicone sheeting for 8 weeks after the ulcer had healed prevented re-ulceration.

Teller P, White TK (2009) The physiology of wound healing: injury through maturation. *Surg Clin North Am* **89**: 599–610

Vinik AI, Maser RE, Mitchell BD, Freeman R (2003) Diabetic autonomic neuropathy. *Diabetes Care* **26**: 1553–66

Weaving L (2014) KerraPro pressure reducing pads in preventing pressure ulceration. Harrogate 2014 Conference Posters. *Wounds UK*. Available at: www.wounds-uk.com/pdf/cases_11518_358.pdf (accessed 02.09.2016)

Westphal et al (2011) A diabetic foot ulcer pilot study: does silicone gel sheeting reduce the incidence of reulceration? *J Am Podiatr Med Assoc* **101**: 116–23