Epidermal wound healing between moist and dry
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Summary

This thesis describes a research-project on a new synthetic wound covering from poly(ether urethane) (PEU) film. The wound exudate does not accumulate underneath this wound covering, because the high water vapour permeability of the PEU film enables evaporation of superfluous exudate. The remaining exudate is concentrated into a jellylike clot. It is known that reepithelialization takes place faster in a moist wound environment than in a dry one. During the last 10 years, therefore, many occlusive wound coverings have become available. The drawback of these wound coverings, however, is that they retain more watery exudate than is required, resulting in bullae formation underneath the covering with risk of tissue maceration and infection. The new wound covering from poly(ether urethane) does not have these drawbacks and is suitable as top layer on biodegradable artificial skin.

In the introduction, chapter 1, the major factors influencing epidermal wound healing are discussed. These factors include type of injury, depth of wound, wound milieu, presence of fibronectin, chemoattractants and growth factors. The presently available wound coverings are categorized to their material origin. Finally, the requirements for an ideal wound covering are discussed and the aim of this investigation is outlined.

In chapter 2, a new measure for the permeability for water vapour of wound coverings is introduced: the water vapour permeance (WVP). The WVP of a wound covering is the steady flux (gram per hour) of water vapour per square meter wound covering induced per kilopascal vapour pressure difference, g·m⁻²·h⁻¹·kPa⁻¹. The WVP enables meaningful comparison of results obtained from other studies, because it corrects for temperature and humidity.

In chapter 3, a new histological staining technique is introduced, necessary to visualize the PEU membrane with the light microscope. Sudan black B, usually a stain for all kinds of lipid, turned out to be an excellent histological stain for polymeric biomaterials embedded in glycol methacrylate. By staining the surrounding connective tissue with toluidine blue-basic fuchsin, the polymer-tissue interface could be studied in detail.

In chapter 4, 5 and 6, the experimental PEU wound covering with a high vapour permeability was compared with an occlusive fluid-retaining wound covering (OpSite®) and with uncovered, air-exposed controls in partial-thickness wounds of guinea pigs.

In chapter 4, the rate of reepithelialization, epidermal thickness and scab thickness was studied in 122 wounds. The percentage of reepithelialization on day 2 was 85% in wounds covered with the permeable PEU membrane, whereas it was 66% and 35%, respectively, in wounds covered with the occlusive covering or those exposed to air. We conclude that the PEU wound covering accelerates epidermal wound healing. This wound healing promotion effect is apparently due to the high water vapour permeability of PEU, which induces concentration and jellification of the wound exudate into a clot layer.

In chapter 5, the effects of wound coverage on epidermis regeneration and evaporative water loss were studied. The evaporative water loss reflected the three phases of epidermis regeneration: a lag period until epidermal resurfacing is complete, followed by fast reduction of vapour loss during parakeratotic keratinization and finally a gradual restoration of the skin water barrier during maturation of a stratum corneum. The evaporative water loss in PEU-covered wounds was initially almost equally raised as that in uncovered wounds, but decreased in four days to levels found in OpSite-covered wounds. In uncovered wounds this level was only reached after seven days, parallel to a delayed healing time. In wounds occluded with OpSite this phasic EWL behaviour was inhibited, due to the shielding effect of the
relative impermeable of OpSite® covering. It was concluded that the PEU wound covering has an ideal water vapour permeance of 22 g·m⁻²·h⁻¹·kPa⁻¹ in vivo, as witnessed by an initially increased EWL, the accelerated epidermal regeneration and the subsequent restoration of the skin water barrier.

In chapter 6, fibrin, fibronectin, type IV collagen and keratin were localized with immunohistochemical techniques in wounds under the three formerly described conditions. The first two proteins form the skeleton of the provisional matrix, which is used by keratinocytes for guidance and anchorage during migration. From this study it was found that these adhesive proteins precipitated more under the PEU membrane than under OpSite, which possibly explains the accelerated reepithelialization. Furthermore, it was found that keratinocytes, while they dissect themselves a path through the provisional matrix, contain fibrinogen, and to a lesser extent fibronectin. This strongly suggests that keratinocytes can phagocytize components from the provisional matrix.

In chapter 7, the PEU wound covering was compared with tulle gras treatment on 20 split-skin donor sites. All patients experienced no pain or almost no pain from their PEU-covered area, whereas 70% of the patients notified more pain from the tulle gras-covered area. It was concluded that the current clinical use of PEU wound covering on donor sites reduces pain considerably and prevents fluid retention, but does not enhances reepithelialization more than tulle gras dressing packed in sultry gauzes and bandages.

In the general discussion, chapter 8, it is stated that the PEU wound covering combines ideal properties, such as a high water vapour permeance, impermeability to bacteria, elasticity, hydrophilicity, transparency, adherence to fibrin, and prevention of tissue incorporation. The significance of the PEU wound for patients with partial-thickness wounds is a shorter healing time with less pain.