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In vitro measurements of burn dressing adherence and the effect of interventions on reducing adherence

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ABSTRACT

Purpose: There is a paucity of research on reducing dressing adherence. This is partly due to lack of an in vitro model, recreating the clinical variability of wounds. Previously we described an in vitro gelatin model to evaluate adherence in a standardized manner. We present evaluation of strategies to reduce adherence in six dressings.
Procedures: Dressing materials used were: PET (Control), fine mesh gauze coated in bismuth and petroleum jelly (BIS), nanocrystalline silver (NS), wide mesh polyester coated in polysporin ointment (WM), fine mesh cellulose acetate coated in polysporin ointment (FM), and soft silicone mesh (SIL). The dressing material was applied to gelatin and incubated for 24h. Adherence was tested using an Instron 5965 force-measurement device. Testing was repeated with various adherence reducing agents: water, surfactant, and mineral oil.
Results: Adherence from least to greatest was: SIL, NS, BIS, WM, FM, PET. Water reduced adherence in all dressings; the effect increasing with exposure time. Surfactant reduced adherence of NS. Mineral oil effectively decreased adherence of BIS, and WM.
Conclusion: This model allows for reproducible measurement of dressing adherence. Different interventions affect various dressings. No single intervention optimally decreases adherence for all dressings.

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1. Introduction

Optimal care of burn injury remains a complex practice that in addition to surgical intervention utilises frequent dressing changes in an attempt to prevent infection and promote healing. Ideal burn dressing characteristics include absorbency, antimicrobial activity, and non-adherence [1]. While absorbency and antimicrobial activity are well studied [2,3], research on dressing adherence is lacking [4–6].

Removal of adherent dressings during dressing changes is directly associated with pain often involving the use of narcotic analgesics and even conscious sedation [7]. Furthermore, if a dressing is adherent, removal may damage the regenerating epithelium and negatively impact wound healing [8]. The effects of dressing change related pain extend beyond the physical, and have been associated with development of posttraumatic stress disorder and depression after burn injury [9,10]. In a recent survey, Selig et al. found that adherence was viewed as one of the most important dressing characteristics desired by burn care providers [11].

While absorbency and antimicrobial activity are measurable in the laboratory, adherence has posed a challenge [1]. Enterline and Salisbury described in 1980 a device for evaluating adherence of burn dressings by measuring pulling force. However this device was never evaluated in clinical use [1]. Since then, the most commonly reported method of evaluating adherence is performance of in vitro cellular adherence testing [6,12] which utilizes a solution with hydrophobic cells that does not reflect the complex environment of a wound with hydrophilic proteins. Alternative strategies have measured the force of skin graft adherence [13,14]. However, the process of skin graft adherence is different from that of dressing adherence as a complex burn wound involves other factors such as proteinaceous exudate. In addition, there is minimal evidence in the literature for what constitutes an acceptable level of adherence.

The environment of and open wound or burn injury is multifaceted with not only protein but also cells and bacteria. Although an in vivo model would be ideal, these models are both difficult to run and expensive. Before embarking on a randomized controlled trial on either humans or animals, it is needed to screen the interventions using a low cost in vitro model with reasonable fidelity. Previously, we described an in vitro gelatin based model of adherence that was found to be responsive to humidity, temperature, and time [15,16]. Based on this model, we have measured adherence in vitro of commonly used burn dressings, and the effects of various interventions on dressing adherence. Herein we quantify adherence of commonly used dressings in burn care, as well as the effect of various interventions on decreasing dressing adherence.

2. Materials and methods

Using previously published standardized protocols, gelatin models were prepared [15]. A rectangular polytetrafluoroethylene (PTFE) frame with inner dimensions $16 \times 60 \times 3$ mm was placed on top of a strip of dressing slightly larger (a mm) than the outside of the mold. Dressings tested included: polyethylene terephthalate (PET), the base material for many dressings; fine mesh gauze coated in Bismuth and petroleum jelly (BIS); nanocrystalline silver (NS); wide mesh polyester coated in petroleum jelly (WM); fine mesh cellulose acetate coated in petroleum jelly (FM); and soft silicone mesh (SIL). A standard amount (0.15 ± 0.05 g) of double antibiotic ointment (polymyxin and bacitracin) was added to each individual strip of those dressings lacking native anti-microbial agents (WM, FM, and SIL). This was done to reflect the routine practice at our center.

40% w/v gelatin was poured into the frame and allowed to set. After setting, the entire complex was placed in an incubator at what has been described as the optimal wound healing environment (32 °C and 75% relative humidity) [17]. (Fig. 1) Our previous study has shown our model to be sensitive to humidity changes, however this specific humidity was chosen to best emulate a moist wound environment [15]. After 24 h the samples were removed from the incubator and the respective molds and immediately analyzed. (Fig. 2) The time the samples spent outside the incubator was minimized as much as possible. The dressing was then peeled off the gelatin using an Instron 5965 (Instron, Norwood, MA) force-measurement device with a 180° peeling force test at a constant rate of 100 mm/min. The Instron 5965 is a universal mechanical testing apparatus, that is not specifically designed for one end use. It offers very high accuracy and precision, load measurement accuracy to +/−0.5% of reading down to 1/1000 of load cell capacity. It is the gold standard for mechanical testing including tensile strength and adherence testing. Adherence is a function of both pulling force and velocity; the Instron 5965 provides both of these at a constant rate. Testing was repeated a minimum of five times and ≥ 3 most consistent trials were used for analyses.

Measurements obtained from the Instron machine were plotted as a function of adherence (N) against distance of peel (mm), with the x-axis ranging from 0 to 100 mm. (Fig. 3) For the analysis, the range between 20 and 80 mm was measured as there was increased variability near the beginning and the end of peeling test. An Excel (Microsoft Excel for Mac 2011) algorithm was used to automatically identify the five highest

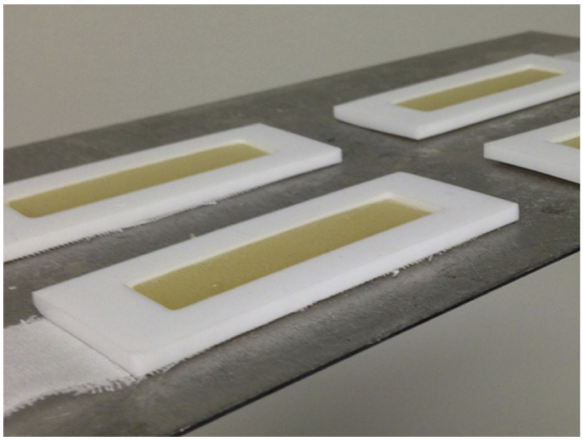

Fig. 1 – Gelatin is poured into a PTFE frame which is placed on top of the dressing strip to be tested.