Super-absorbent dressings: how do they perform in vitro?

Keith F Cutting and Samantha J Westgate

Abstract

The free swell and absorption capacity under compression of six wound dressings that are indicated for moderately to highly exuding wounds was investigated. Measuring in vitro the absorptive capacity and retention under compression is important in terms of clinical efficacy and efficiency. This in vitro comparative study demonstrated that sorbion sachet EXTRA had the highest free swell capacity of the six test dressings and absorbed more than twice the volume (126%) of the test solution than its nearest competitor. When measuring capacity under compression, sorbion sachet EXTRA absorbed 88% more fluid than the nearest competitor.

Key words: Free swell ■ Wound dressing ■ Absorbency

Wounds, particularly chronic wounds can have a significant impact on patient quality of life (Cutting, 2010) and their management requires prudent use of the resources that are most appropriate in the given clinical circumstances. Dressings are applied to wounds for a variety of reasons including protection, prevention of blood loss and other fluids, to provide the optimal environment for healing, for aesthetic reasons, and for the absorption of wound exudate. Clinician requirements in terms of wound dressing performance are becoming more complex but there remains a need for sustained efficiency in terms of the management of exudate. Wound healing is a dynamic process and although wound exudation is a visual manifestation of the inflammatory response (Bishop et al, 2003), the volume of exudate produced together with its consistency and chemical composition can vary considerably between patients and over time. Measuring the fluid-handling capabilities of dressings is of importance when considering the absorptive capacity and the ability to retain the absorbed fluid under application of external pressure. These performance attributes have strong implications in terms of efficacy and associated patient outcomes.

In recent years, there has been a considerable increase in the number of dressings that are based on matrices comprising super absorbent polymers (SAPs). Such dressings have achieved escalating attention as they are designed to have increased absorption capacity (Tadej, 2009) and to bind or retain fluid by converting it into a gel, locking it away within the dressing. This action is to protect the wound and peri-wound skin from enduring contact with an excessively moist/wet dressing interface. Consequently, these dressings are designed to be most appropriate for application to moderate to highly exuding wounds. Poor exudate management increases patient morbidity and costs for the healthcare facility (White and Cutting, 2006). The increasing interest shown in the exudate-handling capabilities of modern dressings may be seen in experimental work undertaken by McCall and colleagues investigating real-time monitoring of wound dressing moisture levels in vitro (McCall et al, 2007). In additional in vitro tests, Thomas identified marked differences in product performance that he considered could be reflected in treatment cost (Thomas, 2010).

Dressings containing SAPs have been designed and constructed with a variety of polymers of varying specifications that may or may not be combined with other components that influence dressing performance. As the mere presence of SAPs does not guarantee optimal wound dressing performance, the fluid-handling characteristics of different technologies have been assessed. Clinicians should be conversant with the performance attributes of available dressings so that fully informed decisions on dressing choice can be made.

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Free swell and absorption under compression

Free swell is a 'dunk-and-drip' test that measures the uptake of fluid by a dressing following a period of immersion (dunk) in the test solution and then allowed to drain (drip). This test method provides a numerical value of dressing absorbent capacity and is most relevant clinically to those wounds that are not subjected to application of pressure from external sources such as abdominal surgical wounds or thigh graft donor sites. In these situations, the dressing is kept in place by a retention device, e.g. adhesive tape or a light conforming bandage. Often, wounds that produce large volumes of exudate such as venous leg ulcers require application of a bandage or hosiery that exerts an externally applied pressure

of approximately 40 mmHg at the ankle. The compression device retains the dressing in place and exerts a pressure, not only on the lower limb but also on the dressing, that has been applied to the ulcer at far greater levels than would be found with a simple conforming bandage or adhesive tape. Compression, therefore, influences the fluid-uptake characteristics of the wound dressing and compromises its absorbent capacity and retention capabilities.

The objectives of this study were to:

- Compare the free swell (absorptive) capacity of six popular wound dressings used in the management of moderately to heavily exuding wounds
- Compare the absorbent capacity under compression of the same six wound dressings.

The in vitro tests reported here have employed recognised methods that are devised to measure free swell and absorption under compression of six wound dressings.

In addition to existing data relating to dressings' clinical performance and patient acceptance, it is the intention that the data reported here will provide a point of reference for clinicians and indeed medicine managers, and facilitate dressing choice.

Methods

Test dressings used were sorbion sachet EXTRA (sorbion GmbH & Co. KG), Curea P1 (Curea-Medical GmbH), Cutisorb Ultra (BSN Medical), DryMax EXTRA (Absorbest AB), Flivasorb (Lohmann & Rauscher), Kerramax (Crawford Healthcare).

Data in respect of free swell and absorbent capacity under compression were prepared by an independent testing laboratory; SAS Hagmann GmbH, Weberstrasse 3, D-72160 Horb am Neckar, Germany.

A comparison between the unit cost of each dressing and the average cost of absorption per 100 ml absorbed will also be made.

Experiment 1

The free swell capacity of absorbent primary wound dressings followed the standard EN13726-1:2002 except where indicated below. The test dressings were weighed using a calibrated balance and then immersed in a tank containing a test solution of NaCl 0.83% with CaCl2 0.037% at 37ºC where they remained for 30 minutes. Dressings were removed from the solution, transferred onto a grid and then into an empty receiving tray, where they were allowed to drain for 30 seconds before being re-weighed. The volume of fluid used was equivalent to 40 times the weight of each dry dressing. In order to enhance the clinical relevance of this in vitro test, commercially available dressings measuring 10 cm x 10 cm were tested in each case instead of 5 cm x 5 cm dressings as indicated in the EN standard. All dressings were tested in triplicate and the mean absorbency was calculated.

Experiment 2

The test dressings were weighed using a calibrated balance and then placed on a perforated metal tray. A weight of 5.42 kg was then placed on the surface of the dressing so that a pressure equivalent to 40 mmHg could be evenly applied to the dressing surface. The tray and the dressing were then immersed in a test solution of NaCl 0.83% with CaCl2 0.037% for 30 minutes at room temperature. The dressings were removed from the test solution and then re-weighed. The absorbent capacity was then determined as the difference in weight between the wet dressing after 30 minutes of uptake (with an additional 5 minutes of drainage) and the dry state. Dressings were tested in triplicate and the mean absorbency was calculated.

Statistics

Two-tailed t-test was used to compare the free swell absorption capacity of the dressings and also the absorption capacity under compression of the test dressings. Statistical tests were carried out using Microsoft Excel 2011 and p values of <0.05 were considered significant.

Results

Experiment 1

The sorbion sachet EXTRA 10 cm x 10 cm dressing absorbed 224 ml of the test solution (*Figure 1*). This was the highest free swell capacity of the six test dressings and equated to 126% more of the test solution than its nearest competitor ($p<0.001$).

There were also significant differences in free swell absorption between the other dressings as shown by the p values in *Table 1*.

Flivasorb absorbed significantly more than Cutisorb Ultra ($p=0.0014$) and KerraMax ($p<0.0001$). Cutisorb

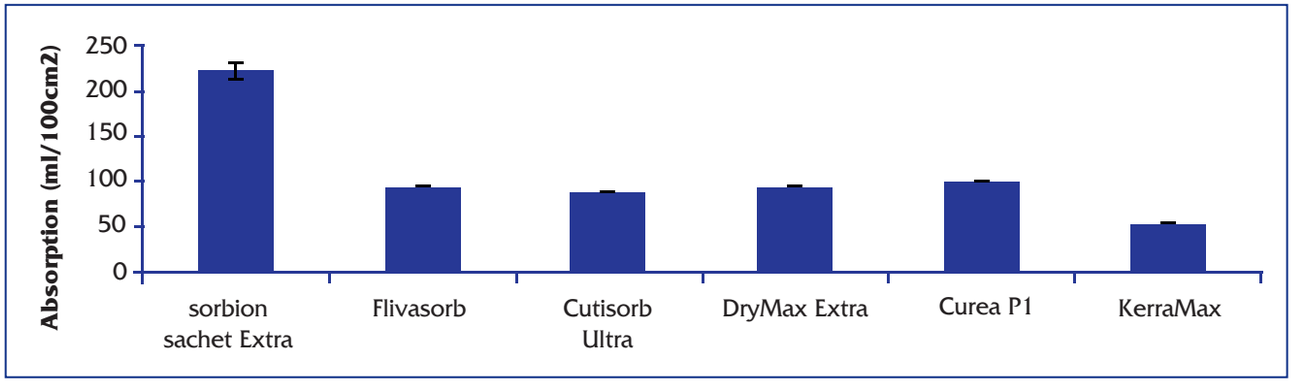

Figure 1. Mean free swell capacity of six unmodified 10 cm X 10 cm test dressings. Error bars indicate the standard deviations.

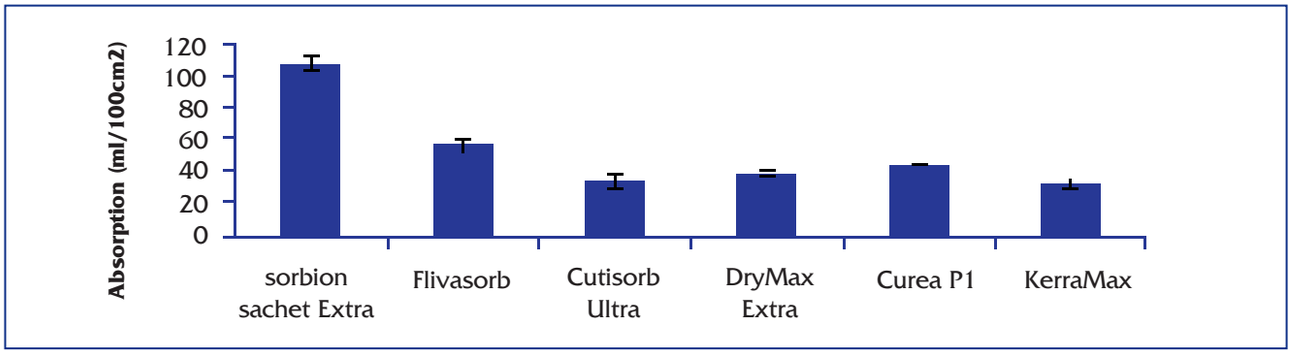

Figure 2. Mean absorbent capacity of six unmodified 10 cm X 10 cm test dressings under compression equivalent to 40 mmHg. Error bars indicate the standard deviations

Table 1. Level of statistical significance in free swell absorbency between the six test dressings. ns = no significance

	Cutisorb Ultra	Curea P1	Flivasorb	DryMax Extra	sobion sachet Extra	KerraMax
Cutisorb Ultra						
Curea P1	p=0.0003					
Flivasorb	p=0.0014	N/S				
DryMax EXTRA	p=0.0001	p=0.0059	N/S			
sobion sachet EXTRA	p<0.0001	p<0.0001	p<0.0001	p<0.0001		
KerraMax	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p<0.0001	

Table 2. The actual cost of a single 10 cm x 10 cm dressings (Drug Tariff, August 2012) and the mean cost per 100 ml fluid absorption.

Dressing	Price (£)	Mean cost per 100ml absorbed (£)	Standard deviation
sorbion sachet EXTRA	2.25	1.00	±0.35
Kerramax	0.93	1.72	±0.02
Drymax EXTRA	1.84	1.94	±0.009
Curea P1	2.10	2.12	±0.31
Flivasorb	2.20	2.27	±0.04
Cutisorb Ultra	2.05	2.30	±0.01

Ultra absorbed significantly more than KerraMax ($p < 0.0001$). Curea P1 absorbed significantly more than KerraMax ($p < 0.0001$), Cutisorb Ultra ($p=0.0003$) and DryMax EXTRA ($p=0.0059$). DryMax EXTRA absorbed significantly more than Cutisorb Ultra ($p=0.0001$).

The mean cost per 100 ml absorbed of the test solution per dressing in ascending order may be seen in *Table 2*.

Experiment 2

The absorption capacity of all the dressings was decreased compared with the free swell absorption (*Figure 1* and *Figure 2*). The sorbion sachet EXTRA dressing absorbed 107 ml/100 cm^2 and was 88% more absorbent than the nearest competitor ($p=0.0001$). The absorption trends of the dressings were similar to those observed in the free swell study.

Significant differences were found in absorption under compression between the other dressings as shown by the p values in *Table 3*.

Flivasorb absorbed significantly more than Curea P1 ($p=0.0023$), DryMax EXTRA ($p=0.0012$), Cutisorb Ultra ($p=0.0023$) and KerraMax ($p=0.0004$). Curea P1 absorbed significantly more than DryMax EXTRA ($p=0.0124$),

Table 3. Differences in the absorbency under compression reported between the six test dressings. ns= not significant

	Cutisorb Ultra	Curea P1	Flivasorb	DryMax EXTRA	sobion sachet EXTRA	KerraMax
Cutisorb Ultra						
Curea P1	N/S					
Flivasorb	p=0.0023	p=0.0023				
DryMax EXTRA	N/S	p=0.0124	p=0.0012			
sobion sachet EXTRA	p<0.0001	p<0.0001	p=0.0001	p<0.0001		
KerraMax	N/S	p=0.0008	p=0.0004	p=0.0215	p<0.0001	

Table 4. The actual cost of a single 10 cm x 10 cm dressings (Drug Tariff, August 2012) and the mean cost per 100 ml absorbed under compression

Dressing	Price (£)	Mean cost per 100ml fluid absorbed under compression (£)	Standard deviation
sorbion sachet EXTRA	2.25	2.10	±0.08
Kerramax	0.93	3.00	±0.22
Flivasorb	2.20	3.87	±0.22
Curea P1	2.10	4.79	±0.02
DryMax EXTRA	1.84	4.84	±0.29
Cutisorb Ultra	2.05	6.27	±0.91

and KerraMax (p=0.0008). DryMax EXTRA absorbed significantly more than KerraMax (p=0.0215).

The mean cost per 100 ml absorbed under compression of the test solution per dressing in ascending order may be seen in *Table 4*.

Discussion

Inadequate management of wound exudate can have disastrous results for the patient and cause maceration of the peri-wound skin and consequential delays in healing. When healing is delayed, there is an increased risk of ensuing infection that will not only increase patient morbidity but also increase costs for the healthcare facility in terms of material resources and nursing time (Wolcott et al, 2010). This highlights the importance of diligence in wound dressing choice.

The experiments reported here clearly emphasise that 'effectiveness' in wound care products that share, or are said to share, one or more ingredients are likely to deliver widely varying results. Clinicians have a responsibility to identify and select clinical interventions that are expected to achieve optimal patient outcomes within the relevant clinical circumstances (Cutting and White, 2012). Therefore, in managing moderately to highly exuding wounds, patients require wound dressings that will not only absorb a large volume of fluid but will also retain that fluid when subjected to external pressures similar to those exerted by graduated external compression bandages.

The level of performance (free swell) has implications not only in terms of patient management but also in costs to the care facility/provider. *Table 2* and *Table 4* do not take into account other potential cost implications when considering nursing time to change patient dressings that require more frequent attention as they have a lower absorptive capacity.

There is a risk that the concept of unit cost may be used as a criterion for dressing selection and thereby discount use of those products perceived as 'too expensive' in the SAP category. Focusing on unit cost as the sole criterion for dressing choice is a misguided attempt at cost containment. When managing moderate to heavily exuding wounds, an alternative approach is to consider dressing performance in terms of fluid-handling costs of absorption/retention. Different dressings have specific design and material characteristics that inevitably lead to variations in performance. The sorbion sachet EXTRA dressing is the least expensive per 100 ml absorbed in both free swell and under simulated compression circumstances.

When managing patients with wounds that produce

moderate-to-high levels of exudate, it is essential that dressing choice decisions are based on fundamental performance attributes. However, it is important to state that the application of in vitro test methodology should be viewed as no more than a guide and not be regarded as an alternative to human disease in vivo testing. It is acknowledged that, clinically, the consistency and rate of production of exudate varies from the described test methodology. In addition, the weight of the dressing increases as it absorbs exudate and this may be at a level inconsistent with patient comfort. This event should be regarded as a clinical indication that the dressing should be changed. Nonetheless, the use of in vitro tests in the selection of wound care products has provided guidance on the physical characteristics of dressings for a number of decades, e.g. vapour permeability (Erasmus and Jonkman, 1989), odour containment (Thomas et al, 1998) and absorbency (Thomas and Fram, 2001).

Scientific data of comparative wound dressing absorbency performance in terms of free swell and absorbency under compression assists in laying the foundations upon which clinical decisions can be made. This should lead us away from relying on unit cost of dressing as a discrete criterion for dressing selection and encourage the inclusion of clinician/patient satisfaction data.

Conclusion

Advanced wound dressings are designed with specific function(s) in mind and this functionality will be determined by the dressing's material properties. Although the polymer dressings reported here are claimed to be suitable for moderate to highly exuding wounds, clinicians need to bear in mind that unit cost of dressing and the associated costs related to nursing time and dressing change interval should be included in the decision-making process.

Variation in wound dressing performance is a consequence of the inherent design and material characteristics. Clinicians should carefully discriminate between products and base their choice on the desired performance outcomes/functions that are supported by sound evidence. These would include the absorbent capacity potential and the ability to retain the absorbed effluent within the dressing matrix where a moist (not wet) environment is maintained also under compression. BJN

Declaration of interest: Perfectus Medical Ltd carried out data analysis of absorbency in vitro data undertaken by SAS Hagmann, GmbH, Germany. The authors had no involvement either with the choice of test methods, the range of dressings included in the study, and have no financial interests in any of the products concerned. The analysis of data and manuscript does not imply approval or endorsement of any products mentioned and was funded by an unrestricted grant from sorbion GmbH & Co.

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KEY POINTS

- Unit cost of wound dressings should not be used as a sole criterion for dressing selection
- Clinicians should take into account the costs of dressing fluid-handling capabilities such as absorption and retention when selecting dressings
- Different dressings have specific design and material characteristics that lead to variations in performance
- Wound dressing absorptive capacity can be influenced by external compression