

## TECHNOLOGY UPDATE:

### Rediscovering alginate dressings

It is approaching 30 years since the first commercially available alginate wound dressing was launched in 1983. This review revisits this group of wound dressings and traces their development, mode of action and use in clinical practice. The author concludes by posing questions about the future for alginate dressings and identifying unanswered questions related to their role in wound healing.

Author:  
Michael Clark

#### INTRODUCTION

While the use of alginate wound dressings dates back 30 years there are anecdotal reports of the use of seaweed to treat wounds dating back to Roman times. In folklore seaweed was also said to have been used by sailors to stem blood loss and by doctors in 18th century Scotland to drain abdominal wall abscesses<sup>[1-2]</sup>. While interesting, these anecdotes are difficult to verify through primary sources.

After the second world war, the use of alginate dressings as haemostatic agents was reported both *in vitro* and in clinical studies. They were also used in wound healing, initially in surgical wounds then in accident and emergency departments, leading to a widespread use of alginate dressings in surgical specialities across 70 UK hospitals<sup>[1]</sup>.

#### BACKGROUND

Alginates are extracted from a variety of species of seaweeds, most notably:

- ▶ Laminaria (mainly harvested in Scotland, Ireland, Norway, France, China, Japan and North and South Korea)
- ▶ Macrocystis (harvested in North America)
- ▶ Ascophyllum (harvested in inter-tidal areas in Scotland, Ireland and Canada)<sup>[3]</sup>.

The manufacture of alginates was first described in the late 1800s, although commercial production began in the 1930s<sup>[2]</sup>, with alginates used for a wide variety of applications, including:

- ▶ Textile printing
- ▶ Food
- ▶ Paper

- ▶ Welding rods
- ▶ Pharmaceuticals.

However, no more than 4% of the commercial production of alginates in the 1930s was used in wound healing<sup>[3]</sup>.

The adoption of alginate dressings was effectively halted in the early 1970s when cheaper materials replaced alginate within the textile printing industry, thus making the limited use of alginates in healthcare commercially non-viable<sup>[1]</sup>.

An upsurge in the use of alginates in the early 1980s arose through a growing interest in the treatment of acute and chronic wounds. Between 2011 and 2012 there were 19 different alginate dressings available in the UK<sup>[4]</sup>.

#### MAKING ALGINATE DRESSINGS

When alkaline is extracted from the seaweed and subsequently filtered, alginic acid is produced. Alginic acid is a linear polymer with two monomers ( $\beta$ -D-mannuronic acid and  $\alpha$ -L-guluronic acid). The monomers are joined together in one of three chains:

- ▶ All  $\beta$ -D-mannuronic acid (M group)
- ▶ All  $\alpha$ -L-guluronic acid (G group)
- ▶ Alternating units of  $\beta$ -D-mannuronic acid and  $\alpha$ -L-guluronic acid (MG group)<sup>[3]</sup>.

Different seaweeds give rise to varying ratios of M, G and MG groups within the alginic acid, with seasonal changes in the ratio of M to G groups also seen within species<sup>[3]</sup>.

The alginic acid is then mixed, either with sodium carbonate or sodium hydroxide, to form sodium alginate. If this is forced under pressure through fine apertures into a solution

#### References

1. Thomas, S. *Surgical Dressings and Wound Management*. 2010; Medetec Publications, Cardiff.
2. Wolters Kluwer Health. *Seaweed*. Available at: <http://www.drugs.com/npp/seaweed.html> (accessed 11 March, 2012).
3. McHugh, DJ. Production, properties and uses of alginates. Available at: <http://www.fao.org/docrep/X5822E/x5822e04.htm> (accessed 11 March, 2012).

## Page Points

1. Alginates are extracted from a variety of species of seaweeds.
2. Probably the major reason for selecting an alginate dressing is to manage wound exudate.
3. Alginate dressings are manufactured in a range of presentations from flat sheets to rope and ribbons.

## References

4. MA Healthcare Ltd. *Wound Care Handbook* 2011–2012. MA Healthcare Ltd, London.
5. Richards AJ, Hagelstein SM, Patel GK, Ivins NM, Sweetland HM, Harding KG. Early use of negative pressure therapy in combination with silver dressings in a difficult breast abscess. *Int Wound J* 2011; 8(6): 608–11.
6. Opanson S, Magnette A, Meuleneire F, Harding K. Askina® Calgitrol® Made Easy. *Wounds Int* 2012; March 3(1).
7. Chrisman CA. Care of chronic wounds in palliative care and end-of-life patients. *Int Wound J* 2010; 7(4): 214–35.
8. Sweeney IR, Miraftab M, Collyer G. A critical review of modern and emerging absorbent dressings used to treat exuding wounds. Available at: <http://onlinelibrary.wiley.com/doi/10.1111/j.1742-481X.2011.00923.x/abstract> (accessed 8 May, 2012).

of a calcium salt, fibres of calcium alginate are formed. This provides the foundation for alginate wound dressings<sup>[1-3]</sup>.

Alginate solutions will react with many divalent or trivalent cations to form gels, with the nature of the gel strongly dependent upon the mix of M, G and MG groups in the alginate. Alginates that are high in M groups have a flat ribbon-like molecular appearance while areas high in G groups have a much more buckled chain shape.

These differences in molecular appearance affect gel formation, with high M alginates forming gels quicker, with a softer and more elastic gel than that produced by a G-rich alginate, which holds calcium and forms a gel slowly<sup>[3]</sup>. G-rich alginates form gels slowly as the buckled shape acts as an 'egg box' into which the calcium ions are packed<sup>[3]</sup> and held strongly (chelated) by the structure of the tetrahydropyran ring of the  $\alpha$ -L-guluronic acid monomer and the presence of hydroxyl oxygen atoms<sup>[1]</sup>.

To accelerate gel formation, a mix of sodium alginate and calcium alginate fibres are incorporated into an alginate dressing, with the sodium alginate added to accelerate the gelling process. Therefore, alginate dressings may vary both in their composition of calcium alginate and sodium alginate fibres, but also in the proportion of M and G groups present within each of the two alginate fibres.

## INDICATIONS AND CONTRAINDICATIONS

Alginate dressings have three main characteristics that influence their indications for use. These are their ability to:

- ▶ Provide a moist environment at the wound bed
- ▶ Absorb exudate
- ▶ Achieve haemostasis<sup>[5]</sup>.

In addition, they are able to reduce wound pain, lower the bio-burden of the wound, reduce odour and absorb proteinases<sup>[6-8]</sup>. If there is prolonged or atypical inflammation then the wound produces abnormally high levels of proteinases, which have a detrimental effect on cell proliferation and growth factor production. Therefore, absorption of the proteinases into the wound dressing potentially lowers the elevated proteinase level and its detrimental impact on the healing process.

There are some contraindications for the use of alginate dressings including:

- ▶ Dry wounds
- ▶ Wounds with minimal exudate
- ▶ Surgical implantations

- ▶ Allergies to any components of the dressing
- ▶ Third degree burns.

In addition, great caution should be taken when alginates are used in the dressing of tumours with friable tissue, which will have exposed blood vessels, as removal of the dressing may cause fresh bleeding.

## TYPES OF DRESSING

Alginate dressings are manufactured in a range of presentations from flat sheets to rope and ribbons<sup>[4]</sup>. Flat sheets tend to be used for superficial wounds with the rope and ribbon versions used to lightly pack cavity wounds. Probes are included in some alginate dressing packs to help with packing cavities. However, packing cavities is not recommended if the opening of the wound is smaller than the width of the probe<sup>[4]</sup>.

In addition, there are super absorbent and self-adhesive versions of alginate dressings<sup>[4]</sup>. If the alginate dressing is not self-adhesive the use of a secondary dressing will be required and selection of this secondary dressing may affect the performance of the alginate dressing.

## WHY SELECT AN ALGINATE?

The major reason for selecting an alginate dressing is to manage wound exudate as it is claimed that they can absorb 15–20 times their own weight in wound fluid<sup>[4]</sup>. Given this capacity, it would appear prudent to use a second absorbent dressing, such as a pad or foam dressing as the secondary dressing when alginates are used. Although alginates can absorb much of the exudate produced by a heavily exuding wound, some wounds may exceed the dressing's capacity for fluid uptake. Therefore, a secondary absorbent dressing can be used to contain any excess exudate. However, semi-permeable films have also been used as secondary dressings. A film dressing might be used for a wound exuding less fluid, which would not require an additional (and more expensive) foam dressing.

When an alginate dressing comes into contact with wound exudate there is an ion exchange between the calcium ions in the alginate and the sodium ions in blood or exudate. When sufficient calcium ions are replaced by sodium ions, the alginate fibres swell, partially dissolve and form a gel.

The chemical composition of the alginate dressing also impacts on the dressing's ease of

removal from the wound. G-rich alginates will only swell slightly during use and can be removed as an intact dressing, while dressings high in M alginates will swell to a greater extent and dissolve, allowing them to be removed through irrigation.

Alginates can be used in a variety of wound types where exudate is present, including:

- ▶▶ Pressure ulcers
- ▶▶ Venous leg ulcers
- ▶▶ Diabetic foot ulcers
- ▶▶ Post-operative wounds
- ▶▶ Cavity wounds
- ▶▶ Traumatic wounds
- ▶▶ Malignant wounds
- ▶▶ Pilonidal sinus wounds
- ▶▶ Donor sites
- ▶▶ Partial thickness burns <sup>[6-12]</sup>.

Generally, alginate dressings can be left in place for 5–7 days. However, the dressing should be changed when it has reached its capacity for absorbing wound exudate. This is normally indicated by 'strike through' of fluid to the secondary dressing. In the case of infected wounds, daily inspection of the wound bed may be required.

If the saturated alginate overlaps onto the periwound skin it can cause maceration, therefore, clinicians should cut the alginate to the shape of the wound and apply a periwound skin protectant (such as a no-sting barrier film). Some alginate manufacturers recommend placing the dressing over the wound and the periwound skin with no requirement to cut the dressing to shape<sup>[5]</sup> — if in doubt, the clinician should always follow the manufacturer's instructions. As the volume of exudate reduces there is always the potential for the alginate to adhere to the wound bed if not saturated with wound fluid. In these situations the alginate should be moistened prior to removal and an alternative dressing used to achieve moisture balance at the wound bed.

## FLUID-HANDLING PROPERTIES

Absorbency should be reported as fluid uptake per standard dressing area (100cm<sup>2</sup>) rather than by dressing weight, given that dressings are supplied in a standard size rather than by their weight<sup>[13]</sup>. On this basis, the absorbency of alginate dressings may range<sup>[1]</sup> from 16.16 grams/100cm<sup>2</sup> to 24.7 grams/100cm<sup>2</sup> with absorbency also reduced where compression bandages are used<sup>[1]</sup> (compressed dressings have less capacity for fluid uptake, probably due to changes in their physical shape).

If the alginate is used to control bleeding

it should be removed once haemostasis has been achieved, otherwise the blood-soaked dressing will dry out and adhere to the wound bed making removal difficult and potentially painful for the patient. Alginate dressings are not recommended as a treatment for wounds that are bleeding heavily. These require alternative methods to achieve haemostasis, such as diathermy and cautery.

## SILVER IN ALGINATE DRESSINGS

Alginate dressings have been combined with other materials, for example, carboxymethylcellulose, zinc and silver<sup>[4]</sup>. There has been considerable interest in combining silver and alginate dressings since the addition of silver results in increased antimicrobial activity when tested in laboratory conditions<sup>[14-16]</sup>. This would suggest that the alginate dressings containing silver may be suitable for infected wounds. However, they should be used according to general best practice guidance for antimicrobial dressings<sup>[17]</sup>, which states that for the majority of patients, the initial prescription should normally be for 14 days with a formal review of treatment objectives at around seven days. A review should be conducted at each dressing change by a qualified clinician, and no prescription should extend beyond 14 days without discussion with a local specialist unless previously agreed or indicated by clinical need.

## RELEVANT LITERATURE

Thomas<sup>[1]</sup> provides an excellent review of the use of alginate dressings (along with a wide range of other dressing materials) and this source should be considered as a basic introduction to the use and evaluation of wound dressings.

The commercial production and basic chemistry of alginic acid and the alginates has also been discussed in depth by McHugh<sup>[3]</sup>, while two recent Cochrane reviews detailed the role of alginate dressings in the treatment of diabetic foot ulcers<sup>[18-19]</sup>. Given the paucity of randomised controlled trials that have compared alginates (and other wound dressings), neither review was able to reach a definitive conclusion regarding the value of alginate dressings in diabetic foot ulcer care, with one stating that: 'Currently, there is no research evidence to suggest that alginate wound dressings are more effective in healing foot ulcers in people with diabetes than other types of dressing, however, many trials in this field are very small.'

## References

9. Clark R, Bradbury S. Silvercel Non-Adherent Made Easy. *Wounds Int* 2010; 1(5): 1–6.
10. Harris CL, Holloway S. Development of an evidence-based protocol for care of pilonidal sinus wounds healing by secondary intent using a modified Reactive Delphi procedure. Part 2: methodology, analysis and results. *Int Wound J* 2012; 9(2): 173–188.
11. Higgins L, Wasiak J, Spinks A, Cleland H. Split-thickness skin graft donor site management: a randomized controlled trial comparing polyurethane with calcium alginate dressings. *Int Wound J* 2012; 9(2):126–131.

## Page Points

1. Alginate dressings have been in clinical use since the 1940s

2. However, alginate dressings appear to have lost ground to other wound dressings that also absorb exudate — while there are 19 alginate dressings available in the UK, there are 65 foam dressing products

3. This may simply reflect that many wounds are producing less exudate, thus not prompting the use of an alginate dressing. However, it may also reflect an opportunity for renewed interest in alginate use

## References

12. Ravnskog F A, Espehaug B, Indrekvam K. Randomised clinical trial comparing Hydrofiber and alginate dressings post-hip replacement *Journal of Wound Care* 2011; 20(3) 136–142.
13. Thomas S. Observations on the fluid handling properties of alginate dressings. *Pharm J* 1992; 248: 850–851.
14. Wiegand C, Heinze T, Hipler U (2009) Comparative in vitro study on cytotoxicity, antimicrobial activity, and binding capacity for pathophysiological factors in chronic wounds of alginate and silver-containing alginate. *Wound Repair and Regen* 17(4): 511–21.
15. Percival SL, Slone W, Linton S, Okel T, Corum L, Thomas JG (2011) The antimicrobial efficacy of a silver alginate dressing against a broad spectrum of clinically relevant wound isolates. *Int Wound J* 8: 237–43.
16. Hooper SJ, Percival SL, Hill KE, Thomas DW, Hayes AJ, Williams DW. The visualisation and speed of kill of wound isolates on a silver alginate dressing. 2012; Available at: <http://onlinelibrary.wiley.com/doi/10.1111/j.1742-481X.2012.00927.x/abstract> (accessed 8 May, 2012).
17. Best Practice Statement: The use of topical antiseptic/antimicrobial agents in wound management. 2nd edition. 2011; Wounds UK, London.
18. Dumville JC, O'Meara S, Deshpande S, Speak K. Alginate dressings for healing diabetic foot ulcers. *Cochrane Database of Systematic Reviews* 2012; Issue 2. Art. No. CD009110. DOI: 10.1002/14651858.CD009110.pub2.
19. Dumville JC, Deshpande S, O'Meara S, Speak K. Hydrocolloid dressings for healing diabetic foot ulcers. *Cochrane Database of Systematic Reviews* 2012; Issue 2. Art. No. CD009099. DOI: 10.1002/14651858.CD009099.pub2.
20. Vowden KR, Vowden P. The prevalence, management, equipment provision and outcome for patients with pressure ulceration identified in a wound care survey within one English health care district. *J Tiss Viab* 2009; 18(1): 20–26.

## FUTURE DEVELOPMENTS

Alginate dressings have been in clinical use since the mid 1940s and in commercial production for almost 30 years. However, alginate dressings appear to have lost ground to other wound dressings that also absorb exudate — while there are 19 alginate dressings available in the UK, there are 65 foam dressing products<sup>[4]</sup>. Recent surveys of dressing use show relatively low use of alginate dressings compared with foam products, for example, Vowden and Vowden<sup>[20]</sup> noted that across one English health care district (Bradford), 87 pressure ulcers were dressed with a foam product while only five were covered with an alginate dressing. This may simply reflect that many wounds are producing less exudate, thus not prompting the use of an alginate dressing. However, this may also reflect an opportunity for renewed interest in alginate use.

In the future it may be feasible to achieve increased fluid-handling capacities in alginate dressings with additional benefits such as antimicrobial capability, given the ability to introduce silver and other components. Further development of alginate dressings may also lie in exploring other areas where they may interact with wound healing. In 2010, Thomas<sup>[1]</sup> posed a number of questions, which if addressed might strengthen the role for alginate dressings in wound management:

- ▶▶ Can the chemical composition of alginates be related to healing and wound infection rates?
- ▶▶ Do alginates rich in mannuronic acid stimulate the production of cytokines?
- ▶▶ Do alginates with a high mannuronic acid content absorb bacteria, proteolytic enzymes and toxins?
- ▶▶ Are alginates rich in mannuronic acid help treat infected or malodorous wounds?

To these could be added questions concerning the value of using alginate dressings in exudate that contains blood.

Positive answers to these questions should lead to an increased interest in, and use of, alginate dressings and may form the basis for new research and clinical studies. Thirty years after the first commercial alginate dressing, these are new areas of investigation that could help blend the composition of alginate dressings, thus achieving improved patient outcomes.

## AUTHOR DETAILS

**Michael Clark**, PhD, is Visiting Professor in Tissue Viability, Birmingham City University, Birmingham, UK