Use of hydrogels and iodine in diabetic foot lesions

Vanessa Jones

Introduction

Although not usually the first dressing of choice for a diabetic foot ulcer, both hydrogels and iodine-based dressing materials may, on occasions, provide useful alternatives for practitioners. Improved formulations of hydrogels and advances in our knowledge of the effects of iodine have extended the application of these dressings to cover a wider range of wound problems affecting the diabetic foot.

Hydrogels consist of a matrix of polymers with up to 96% water content. They transmit moisture vapour and oxygen, but their bacterial and fluid permeabilty can be dependent on the type of secondary dressing used (Choucair and Phillips, 1998).

Hydrogels promote wound debridement by rehydrating the wound bed and facilitating natural autolysis. Autolysis is the spontaneous separation of devitalised tissue from healthy tissue, and the process is enhanced in the presence of moisture (Mulder, 1995). In people with diabetes, autolysis is often impaired as the result of inhibition of leucocyte activity (Elkeles and Wolfe, 1991): thus dressings that provide a moist environment can facilitate autolysis.

A variety of hydrogels are currently available and their properties have been reported in a large number of clinical trials and case studies. Their ability to donate water and absorb fluid varies according to their formulation (Thomas and Hay, 1995). Before use, practitioners should consider these differences in relation to the state of the wound.

Hydrogels are available in two forms:

- Sheet form, which has a stable structure
- Amorphous, which has no fixed structure.

Amorphous hydrogels are indicated for the debridement of non-viable tissue in a wide variety of wound types and conditions (Dealey, 1994).

Intrasite, one of the most popular hydrogels, was launched in the 1980s and was originally called Scherisorb. The original formulation included a polymer derived from starch, but the product has since been reformulated with a cellulose polymer.

The new formulation comprises 2.3% carboxymethylcellulose (CMC) polymer, 77% water and 20% propylene glycol. The CMC polymer forms a matrix with water which rehydrates the wound and effects debridement. As the polymer is only partially hydrated, the hydrogel is able to absorb some of the wound exudate (Williams, 1994).

The use of Intrasite as a desloughing agent is well documented in many clinical trials and case studies (Stewart and Leaper, 1987; Thomas and Fear, 1993; Flanagan, 1995; Colin et al, 1996). Intrasite has also been used as a pretreatment on dry gangrene before the application of larvae (Rayman et al, 1998).

Most of these studies, however, have been conducted on patients with pressure sores and leg ulcers; very few have diabetic foot ulcers. There may be several reasons for this. One is that patients with diabetic foot ulcers are often excluded from clinical trials as the presence of slough and necrosis in such patients usually indicates underlying peripheral vascular disease, and a diminished blood supply to the wound area is not the ideal condition in which to demonstrate the healing potential of a dressing.

This lack of evidence should be taken into account by the practitioner before application of a hydrogel to a diabetic foot wound. As always, the practitioner should first assess the patency of the vascular supply to the area of slough and necrosis.

ARTICLE POINTS

1 Hydrogels can be used in conjunction with sharp debridement.

2 Modern hydrogels are able to absorb exudate as well as donate fluid.

3 Iodine dressings can contribute to ulcer cleansing.

4 Cadexomer-iodine has potential as a debriding and anti-microbial agent for use on diabetic foot ulcers.

5 More research into the use of hydrogels and iodine dressings for diabetic foot ulcers is needed.

KEY WORDS

- **Diabetic foot ulcers**
- **Wound infection**
- **Hydrogels**
- **Iodine**

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1 Debridement with hydrogels is indicated following amputation when the wound has broken down, or for large amounts of tissue loss with eschar when removal in theatre is not an option.

2 Hydrogels may be used as an aid to and in conjunction with local sharp debridement.

As discussed in a previous article in this series (Jones, 1998), extreme caution should be exercised when dealing with gangrenous tissue in patients with peripheral vascular disease. The application of a moist dressing, such as a hydrogel, in such patients may result in the spread of infection, with potentially serious consequences.

Problems may arise when dry gangrene occurs next to slough and necrosis, and in such cases it is probably wise to use a sharp debridement technique to avoid these complications.

Growth of bacteria

There is always concern among practitioners about the use of dressings that promote a moist environment, and some avoid their use on wounds that are clinically infected in the belief that they may encourage the growth of bacteria. McCulloch (1993) demonstrated in vitro that Intrasite does not support bacterial growth, owing to its inherent bacteriostatic activity.

Mehtar and Mayet (1996) used Intrasite on infected wounds in five patients, all of whom were taking systemic antibiotics and required daily dressing changes. But since these patients did not have diabetic foot ulcers, it is difficult – and probably unwise – to extrapolate the results to a patient population that is known to have a problem with immunity to infection. Schipani et al (1997), however, were able to demonstrate that there was no bacterial growth at baseline, 24, 48, and 72 hours after the application of Intrasite Gel to eight neuropathic ulcers in six diabetic patients.

Although the use of hydrogels in patients with neuropathic ulcers is debatable, debridement with hydrogels can be used following amputation when the wound has broken down, or for large amounts of tissue loss with hard thick eschar when removal in theatre is not an option (*Figure 1*). Hydrogels may also be used as an aid to, and in conjunction with, local sharp debridement (Figure 2).

Since the launch of Intrasite, many other hydrogels have become available. Aquaform, which has a similar formulation to the original Intrasite (i.e. starch based), is now widely used throughout health authorities even though evidence of its efficacy is based largely on in-vitro work (Thomas and Hay, 1996) and case studies (Thomas and Jones, 1996).

Hydrogels such as Sterigel, Nu-Gel, GranuGel and Purilon provide alternatives to Intrasite and have equally good clinical trial results to validate their use (Gibson et al, 1995; Young et al, 1997; Bale et al, 1998). Some of these new hydrogels are formulated in combination with other dressing materials such as hydrocolloid and alginate.

Whereas the older hydrogels were not the dressing of choice when exudate management was a priority, these newer formulations may provide some increase in absorbency – a property that was not previously associated with hydrogels. The newer hydrogels are also promoted on their cost-effective benefit, as they can be left in place for longer on sloughy wounds, and are able to cope with the exudate over longer periods of time.

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Figure 1. Hydrogel dressing which has been applied to soften hard eschar.

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Figure 2. Hydrogels can be used in conjunction with sharp debridement in wounds with thick slough.

PAGE POINTS

1 Some of the newer hydrogels are formulated with hydrocolloids or alginates, giving them greater absorbency.

2 They are also more cost-effective as they can be left in place for longer on sloughy wounds.

3 Povidone-iodine is an iodophor with wound cleansing and debridement properties.

4 Although it has an established role in skin disinfection, its role as an antimicrobial agent is unclear.

5 Povidone-iodine should not be used in place of systemic antibiotics in infected wounds, particularly in patients with diabetes.

In trials involving patients with leg ulcers (Gibson et al, 1995) and pressure sores (Young et al, 1997), better control of exudate and fewer dressing changes have been reported with the newer hydrogels.

GranuGel, a hydrogel combined with hydrocolloid, and Purilon and Nu-Gel, which are formulated with alginate, may offer some advantage in the management of diabetic foot wounds with a large amount of tissue loss (*Figure 3*) following debridement, provided that they are changed daily.

Many of the trials of hydrogels have used saline gauze as the comparator (Westerhof and Mekkes, 1996; Jensen et al, 1998). In these trials, hydrogels have resulted in a better outcome for patients and proved cost-effective. Cost-effective studies examine many factors, including the number of dressing changes, cost of community nursing time and unit cost of the dressing.

However, these factors cannot always be taken into account when assessing the needs of the patient with a diabetic foot; for example, the position of a foot ulcer may adversely affect the positive properties of hydrogels, resulting in a perceived failure of the dressing to perform as expected.

Iodine

Iodine is an antiseptic that is toxic to living tissue and bacteria (Morgan, 1993). In its molecular form, elemental iodine is almost insoluble in water, can cause skin irritation and hypersensitivity, and can be absorbed systemically (Dela Cruz et al, 1987). These problems have led to the development of iodophores, which are compounds of iodine linked to a non-ionic surfactant (Lawrence, 1998).

There are two commercially available iodine preparations: povidone-iodine and cadexomer-iodine. These preparations have different physical characteristics and different mechanisms of release of iodine (Gilchrist, 1997). Both products have wound cleansing and debridement properties and a possible beneficial effect on the treatment and prevention of wound infection, all of which are potentially important in the care of patients with diabetic foot ulcers.

Povidone-iodine

Povidone-iodine (polyvinyl-pyrrolidone-iodine complex) is an iodophor. Iodophores are compounds of iodine linked to surfactants which act as a carrier for iodine.

Povidone-iodine is bactericidal not bacteriostatic and has the advantage over other iodine preparations that the carrier, polyvinyl-pyrrolidone, has an affinity for the cell membrane and can therefore deliver iodine directly to the cell surface. Its bacterial action increases with dilution (Gordon, 1993), with maximum activity in the range 0.1–1%.

However, its role as an antimicrobial agent is unclear (Zamora, 1986). Mertz et al (1984) reported that in partial-thickness wounds, even after 24 hours exposure to 10% povidone-iodine, very few pathogens were destroyed. A similar conclusion was reached by Lammers et al (1990), who compared 1% povidone-iodine solution with saline gauze, and found no significant difference in bacterial counts from biopsies of acute traumatic contaminated wounds after a 10-minute exposure period.

The use of povidone-iodine as a skin disinfectant, however, is well established. In burns patients, topical povidone-iodine provides effective antibacterial prophylaxis (Lawrence, 1992). The benefit to other wound types is less well documented and povidone-iodine should not be used in place of systemic antibiotics in infected wounds, particularly in patients with diabetes.

The problem is, as always, that much of the work on this product has been carried out in animals or in vitro in laboratory studies (Mayer, 1994; Moore, 1996). It should be borne in mind that fears of its

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Figure 3. Large amount of tissue loss with slough. Maceration may occur if hydrogels are used too extensively.

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1 Cadexomer-iodine comprises a starch lattice containing 0.9% iodine, and has good absorptive properties.

2 Following absorption of fluid, iodine is released slowly into the wound bed.

3 The released iodine removes debris and bacteria from the wound bed, making cadexomer-iodine an effective debriding agent.

4 The most commonly used cadexomer-iodine dressings are Iodosorb (ointment) and Iodoflex (paste).

potentially toxic effect on wound healing originated from animal studies such as those of Geronemus et al (1979) in the pig, Brennan and Leaper (1985) in rabbits, and Kashyap et al (1995) in mice.

Iodine is also diluted by exudate and proteins on the wound surface, and penetration through the tissue causes a concentration gradient that inevitably reduces its toxicity (Moore, 1996).

The most commonly used povidone-iodine dressing is Inadine, an impregnated tulle that does not appear to have any reported systemic effect (Figure 4). Its use in patients with malfunctioning thyroid glands should be avoided. Patients with diabetes who are taking sulphonamides or sulphonylureas, which inhibit thyroid hormone synthesis, should also be observed for possible toxic effects (Johnson & Johnson, 1997). In addition, when used in patients with renal impairment, which often includes those with advanced diabetes, it is recommended that serum iodide concentrations be measured regularly (Aronoff et al, 1980).

Cadexomer-iodine

Cadexomer-iodine is a three-dimensional starch lattice containing 0.9% iodine. It has good absorptive properties: 1 g of cadexomer-iodine can absorb up to 7 ml of fluid (Sundberg and Meller, 1997). Absorption of fluid results in the slow release of iodine, which has the ability to remove debris and bacteria from the wound bed (Moberg et al, 1983; Thomas, 1990).

One of the advantages of cadexomer-iodine, therefore, is that it allows iodine to be delivered over a longer period of time and, in theory, maintains a constant level of iodine in the wound bed. Its ability to remove debris from the wound bed makes it an effective debriding agent.

There is also some evidence that cadexomer-iodine may have a direct biological action. Moore et al (1997) demonstrated that it stimulated the production of tumour necrosis factor from macrophages. Although this was an in-vitro study and the concentration of cadexomer-iodine was 0.25%, it is worthy of further investigation.

The most commonly used cadexomer-iodine dressings are Iodosorb (ointment) and Iodoflex (paste). Various studies have looked at their efficacy:

- Skog et al (1983) suggested that cadexomer-iodine had a positive infection-reducing effect on wounds
- Steele et al (1986) concluded from their study of 28 patients with venous leg ulcers that cadexomer-iodine was effective in dirty, odorous ulcers.
- Sundberg and Meller (1997) found that cadexomer-iodine compared favourably with other dressing types in chronic wounds such as leg ulcers, pressure sores and diabetic foot ulcers.
- Apelqvist et al (1992) found Iodosorb to be potentially useful in the the control of exudate from diabetic foot ulcers
- Apelqvist and Tennvall (1996) compared the effectiveness and cost-effectiveness of Iodosorb in diabetic patients with cavity ulcers, and reported a favourable healing rate.

Although Iodosorb appears to contribute to ulcer cleansing, these trials show that it does not appear to significantly decrease the healing time (Cullum, 1994).

The potential of cadexomer-iodine as a debriding and antimicrobial agent is interesting. Both Iodosorb and Iodoflex are available to community practitioners and could be used effectively for diabetic foot ulcers.

Conclusion

Although there is some evidence to support the use of hydrogels and iodine dressings in diabetic foot ulcers, their major advantages – less frequent dressing changes and a reduction in microbiological load – need to be further investigated with more research.

Of all patients, those with diabetes need more frequent dressing changes than others, and require systemic antibiotics when their ulcers are infected. It is only with this in mind that the practitioner should consider the use of hydrogels or iodine dressings for diabetic foot ulcers. ■

Apelqvist J, Tennvall R (1996) Cavity foot ulcers in diabetic patients: a comparative study of cadomer iodine ointment and standard treatment. *Acta Dermato-Venereologica* **76**: 231-5

Apelqvist J, Larsson J, Stenstrom A (1992) Cadexomer iodine gel in the treatment of deep diabetic foot

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Figure 4. Iodine-impregnated dressings used to aid debridement in a plantar ulcer.

ulcers. In: *Proceedings of the 1st European Conference on Advances in Wound Management.* MacMillan, London: 91-2

Aronoff GR, Friedman SJ, Doedens DJ, Lavelle KJ (1980) Increased serum iodide concentrations from iodine absorption through wounds treated topically with povidone iodine. *American Medical Sciences* **279**(3): 173-6

Bale S, Banks V, Hagelstein S, Harding K (1998) A comparison of the amorphous hydrogels in the debridement of pressure sores. *Journal of Wound Care* **7**(2): 65-8

Brennan S, Leaper DJ (1985) The effect of antiseptics on the healing wound: a study using the rabbit ear chamber. *British Journal of Surgery* **72**: 780-2

Choucair M, Phillips T (1998) A review of wound healing and dressings material. *Skin and Aging* **6**(6; Suppl): 37-43

Colin D, Kurring PA, Quinlan D, Yvon C (1996) Managing sloughy pressure sores. *Journal of Wound Care* 5(10): 444-6

Cullum N (1994) *The Nursing Management of Leg Ulcers in the Community: A Critical Review of Research.* Department of Health. HMSO, London

Dealey C (1994) *The Care of Wounds.* Blackwell Science, London

Dela Cruz F, Brown DH, Leikin JB et al (1987) Iodine absorption after topical administration. *Western Journal of Medicine* **146**: 43-5

Elkeles RS, Wolfe JHN (1991) The diabetic foot: ABC of vascular diseases. *British Medical Journal* **303**: 1053-5

Flanagan M (1995) The efficacy of a hydrogel in the treatment of wounds with non-viable tissue. *Journal of Wound Care* **4**(6): 264-7

Geronemus RG, Mertz PM, Eaglstein WH (1979) Wound healing: the effects of topical agents. *Archives of Dermatology* **115**: 1311-13

Gilchrist B (1997) Should iodine be reconsidered? *Nursing Times* **43**(32): 6-7

Gibson B, Hofman D, Nelson A et al (1995) A clinical investigation of two hydrocolloid gels for the treatment of chronic wounds. Poster presentation, Proceedings of Symposium on Advanced Wound Care, Health Management Publications, Pennsylvania, USA

Gordon J (1993) Clinical significance of MRSA in UK hospitals and the relevance of povidone-iodine in their control. *Postgraduate Medicine* **69**(Suppl 3): S106-S116

Jensen JL, Seeley J, Gillin B (1998) A controlled randomised comparison of two moist wound healing protocols: Carrasyn (hydrogel wound dressing) and wet to moist saline gauze. *Advances in Wound Care: Research Digest* **11**(7): 1-4

Johnson & Johnson (1997) *Inadine: Your Questions Answered.* J&J Medical, Ascot

Jones V (1998) Debridement of diabetic foot lesions. The Diabetic Foot 1(3): 88-94

Kashyap A, Beezhold D, Wiseman J, Beck W (1995) Effect of povidone-iodine ointment on wound healing. *American Surgeon* **61**(6): 486-91

Lammers RL, Foume M, Callahan ML (1990) Effects of povidone-iodine and saline soaking on bacterial counts in acute traumatic contaminated wounds. *Annals of Emergency Medicine* **19**(6): 709-14

Lawrence JC (1998) The use of iodine as an antiseptic agent. *Journal of Wound Care* **7**(8): 421-5

Lawrence JC (1992) Burn bacteriology during the last 50 years. *Burns* **18** (Suppl): S23-S29

Mayer DA (1994) The perils of povidone-iodine use. *Ostomy/Wound Management* **40**(8): 6-8

McCulloch D (1993) An investigation into the effects of Intrasite Gel on the in-vitro proliferation of aerobic and anaerobic bacteria (Poster). *Proceedings of 2nd European Conference on Advances in Wound Management.* MacMillan, London: 207

Mehtar S, Mayet F (1996) *Pilot Study of Intrasite Gel in the Management of Infected Wounds.* Clinical reference guide. Smith & Nephew Healthcare Limited, Hull

Mertz PM, Alvarez O, Smerbeck RV, Eaglstein WH (1984) A new in vivo model for the evaluation of topical antiseptics on superficial wounds: the effect of 70% alcohol and povidone-iodine. *Archives of Dermatology* **120**(1): 58-62

Moberg S, Hoffman L, Grennert ML et al (1983) A randomised trial of cadexomer iodine in decubitus ulcers. *Journal of the American Geriatrics Society* **31**: 462-5

Moore K, Thomas A, Harding KG (1997) Iodine released from the wound dressing Iodosorb modulates the secretion of cytokines by human macrophages. *International Journal of Biochemistry and Cell Biology* **29**(1): 163-71

Moore DJ (1996) The use of antiseptics in wound care: critique 3. *Journal of Wound Care* **5**(1): 46-7

Morgan D (1993) Is there still a role for antiseptics? *Journal of Tissue Viability* **3**(3): 80-4

Mulder GD (1995) Cost-effective management care: gel vs wet-to-dry debridement. *Ostomy and Wound Management* **41**(1)5: 896-900

Rayman A, Stansfield G, Woollard T et al (1998) Use of larvae in the treatment of the diabetic necrotic foot. *The Diabetic Foot* **1**(1): 7-13

Schipani E, Romanelli M, Piaggesi A et al (1997) Long-term application of hydrocolloid gel in neuropathic diabtic foot ulcers: evaluation of sterility. *Proceedings of the 6th European Conference on Advances in Wound Management.* Macmillan, London: 256

Skog E, Arnesjo B, Troëng T et al (1983) A randomised trial comparing cadexomer iodine and standard treatment in the out-patient management of chronic venous ulcers. *British Journal of Dermatology* **109**: 73-83

Steele K, Irwin G, Dowds N (1986) Cadexomer iodine in the management of venous ulcers in general practice. The Practitioner 230(1411): 63-68

Stewart AJ, Leaper DJ (1987) Treatment of chronic leg ulcers in the community: a comparative trial of Sterisorb and Iodosorb. *Phlebology* **2**:115-21

Sundberg J, Meller R (1997) A retrospective review of the use of cadexomer iodine in the treatment of chronic wounds. *Wounds* **9**(3): 68-86

Thomas S (1990) *Wound Management and Dressings.* Pharmaceutical Press, London

Thomas S, Fear M (1993) Comparing two dressings for wound debridement. *Journal of Wound Care* **2**(5): 272-4

Thomas S, Hay NP (1995) Assessing the hydroaffinity of hydrogel dressings. *Journal of Wound Care* **3**(3): 89-91

Thomas S, Hay NP (1996) In-vitro investigation of a new hydrogel dressing. *Journal of Wound Care* **5**(3): 130-2

Thomas S, Jones H (1996) Clinical experiences with a new hydrogel dressing. *Journal of Wound Care* **5**(3): 132-3

Westerhof W, Mekkes JR (1996) *A Pilot Study comparing Intrasite Gel with Saline Soaked Gauze for Debridement.* Clinical reference guide. Smith & Nephew Healthcare Limited, Hull

Williams C (1994) Intrasite gel: to a hydrogel dressing. *British Journal of Nursing* **3**(16): 843-6

Young T, Williams C, Benbow M et al (1997) A study of two hydrogels used in the management of pressure sores. In: Proceedings of the 6th European Conference on Advances in Wound Management. MacMillan, London: 103-106

Zamora JL (1986) Clinical and microbiologic characteristics and toxicity of povidone-iodine solution. *American Journal of Surgery* **151**: 400-6