

# Chitosan: a natural solution for wound healing

Jackie Stephen-Haynes, Elaine Gibson, Michelle Greenwood

An advanced wound care dressing that uses a natural resource in its ability to absorb and retain moisture as well as to provide antimicrobial properties, offers a new multi-functional, biointeractive protease modulator to the wound dressing arena. Several factors indicate the need for such a dressing, namely: an ageing population inevitably increases the prevalence of wounds managed across acute and community settings, the prevention and management of infection remains a priority and the use of natural resources is becoming more important. This article considers the literature supporting this product and, using care study examples, demonstrates its potential impact on patient outcomes.

## KEYWORDS:

Advanced wound care ■ Natural product ■ Retention and gelling capability

Recent years have seen wound care advancing through science, technology and evidence. More advanced dressings, with high absorption capacities and moisture retention capabilities, have become available (e.g. hydrofibers, alginates, foams, superabsorbents) (Jones and Barraud, 2013). In light of the emergence of antibiotic-resistant pathogens, some also include antimicrobial agents such as silver, honey, iodine and, more latterly, polyhexamethylene biguanide (PHMB).

However, despite the wealth of products available in the advanced wound care arena, in the authors' opinion, traditional treatments,

**'To achieve optimal wound management, dressings need to control exudate production so that the wound bed has sufficient moisture to promote wound healing, without letting the volume increase to levels that may be detrimental to the surrounding skin'**

such as gauze, cotton wool and Gamgee, continue to be used in clinical settings, particularly where a tissue viability nurse specialist is not in post to advise. While such traditional products appear less expensive, this is not always the case when considering the number of dressing changes needed, which in turn involves nursing time (Stephen-Haynes et al, 2011).

Maintaining a moist wound healing environment and preventing and managing infection are essential to achieve best practice in wound care. The volume of exudate plays an important part in maintaining this

balance (Cutting and White, 2005; Jones and Barraud, 2013). To achieve optimal wound management, dressings need to control exudate production so that the wound bed has sufficient moisture to promote wound healing, without letting the volume increase to levels that may be detrimental to the surrounding skin (Dowsett, 2008), with the potential to increase the risk of infection developing (Cutting and White, 2005). Alongside this, patient choice and comfort should be considered, with patients being fully informed about their care and having an active say in the treatment chosen (Department of Health [DH], 2010a; Coulter and Collins, 2011).

In addition, with the government agenda to shift the point of care from hospitals to the community in order to reduce costs and bring care closer to home, it is inevitable that more patients with complex wounds will be treated in community settings. Indeed, the DH (2009) have proposed that with the introduction of more advanced wound care products, complex wound care should take place in the community setting, thereby enabling patients who might otherwise have been hospitalised to be treated in their own homes. An ageing population also means that the number of patients needing care for wounds (Ousey et al, 2013), in the form of advanced wound dressings, will increase.

Prevention and management of infection has become a high priority for healthcare professionals but, due to concerns over resistance (European Wound Management Association [EWMA], 2013), clinicians need to use antimicrobial agents wisely and ensure that they choose the most appropriate product

*Jackie Stephen-Haynes, Professor and Consultant, Nurse, Practice Development Unit, Birmingham City University and Worcestershire Health and Care Trust; Elaine Gibson, Tissue Viability Nurse Specialist, East Kent University Hospitals, NHS Foundation Trust, Clinical Manager, Aspen Medical Europe Ltd; Michelle Greenwood, Consultant Nurse Tissue Viability, Walsall Healthcare NHS Trust and Associate Lecturer, Practice Development Unit, Birmingham City University*

for each clinical scenario, dependent on clinical need (Wounds UK, 2013).

Thus, healthcare professionals in the community should be aware of developments in wound management and consider products that both meet their patients' clinical needs (DH, 2010b) and are acceptable to them, while also improving their quality of life by reducing complications such as the risk of damage to the periwound skin, exudate leakage, and infection — i.e. using dressings that contribute to patient wellbeing (DH, 2011; International Consensus, 2012).

Considering this, Aspen Medical have developed a product (KytoCel® gelling fibre dressing) for the management of chronic wounds that harnesses advanced technology with a natural resource, chitosan, and offers the key benefits of high absorption, fluid retention, and a high 'wet strength'.

## CHITOSAN

Chitosan is a naturally-occurring starch (polymer) derived from the shells of crustaceans (Lee et al, 2009). It works by creating a positive charge, hence interacting with negatively charged molecules such as gram-positive bacteria, blood cells, proteins and lipids (Lee et al, 2009).

It also has other proven properties that are beneficial throughout all stages of wound healing (Dai et al, 2011). For example, it:

- ▶ Accelerates healing (Li et al, 1992; Khor and Lim, 2003; Foda et al, 2007; Lee et al, 2009)
- ▶ Stimulates the immune response (Lee et al, 2009)
- ▶ Is antimicrobial (bacteriostatic and fungistatic) (Li et al, 1992; Khor and Lim, 2003; Niekrasewicz, 2005; Foda et al, 2007)
- ▶ Is haemostatic (Li et al, 1992; Khor and Lim, 2003; Niekrasewicz, 2005; Foda et al, 2007)
- ▶ Is non-toxic to the wound bed (Khor and Lim, 2003; Foda et al, 2007; Jayakumar et al, 2011)
- ▶ Manages exudate (Li et al, 1992; Khor and Lim, 2003; Foda et al, 2007)

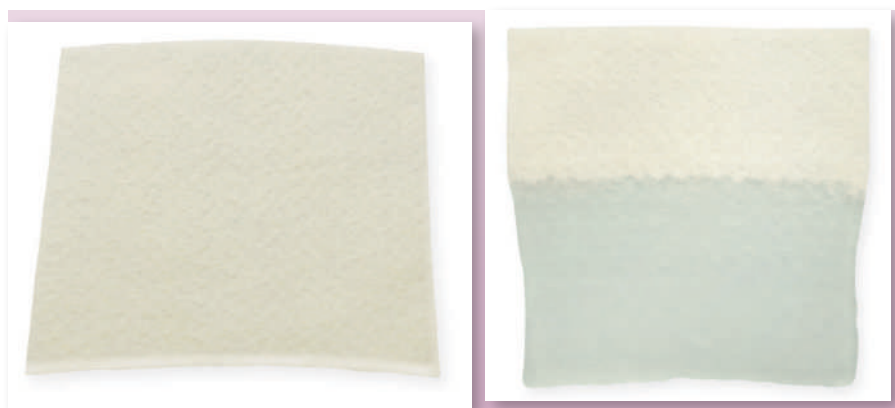


Figure 1.

Flat dressing showing KytoCel's ability to absorb and retain wound fluid.

- ▶ Is biocompatible and biodegradable (Li et al, 1992; Khor and Lim, 2003; Niekrasewicz, 2005; Foda et al, 2007; Jayakumar et al, 2011).

## KYTOCEL® GELLING FIBRE DRESSINGS WITH CHITOSAN

KytoCel® (Aspen Medical) is a highly absorbent dressing composed of natural, biodegradable acylated chitosan fibres using a carding/non-woven process. These fibres bond with wound exudate to form a clear gel that locks-in fluid (Figure 1), absorbs pathogens and is conformable to the wound bed.

The absorbent properties of KytoCel enable it to bind and lock away commonly encountered wound pathogens such as *Escherichia coli*, *Staphylococcus aureus*, *Candida Albicans* and meticillin-resistant

*Staphylococcus aureus* (MRSA), thereby reducing wound bioburden and the risk of cross-contamination at dressing change (Li et al, 1992; Khor and Lim, 2003; Foda et al, 2007).

Due to its absorbent properties, KytoCel locks fluid within its core, reducing the lateral wicking action seen in other exudate management dressings. This means that KytoCel prevents the spread of wound exudate to the edges of the dressing, protecting the periwound skin from potential maceration. The dressing's high wet strength also offers clinicians the ability to remove the dressing in one-piece, as it remains intact even when fully saturated, without leaving behind dressing fibres or residue. This makes dressing changes easier and promotes patient comfort.

The positive charge of chitosan fibres also enables them to halt



Figure 2.

KytoCel product range.

bleeding by binding to negatively charged red blood cells, resulting in faster coagulation. By polymerising with blood to form a net-like structure, the fibres further capture red blood cells leading to clotting (Li et al, 1992; Khor and Lim, 2003; Foda et al, 2007; Niekraszewicz, 2005).

Chitosan also has an accelerating effect on wound healing (Jayakumar et al, 2011) by activating immune cells through its cytokine production, giant cell migration, and stimulating type IV collagen synthesis (Mezzana, 2008). These actions support KytoCel during all stages of tissue repair (Dai et al, 2011).

### Indications

KytoCel is indicated for the management of moderate to heavily exuding acute and chronic wounds, and, due to its haemostatic properties, may be used to control bleeding in superficial wounds.

KytoCel is supplied as a sterile wound dressing and is available as a flat or ribbon variant. It is packed in individual, peel-open sealed packages in multi-pack cartons (Figure 2; Table 1). KytoCel has a number of applications and can be used for the management of:

- ▶ Pressure ulcers
- ▶ Venous leg ulcers
- ▶ Diabetic foot ulcers
- ▶ Cavity wounds (ribbon dressing, Figure 3)
- ▶ Donor sites and graft sites
- ▶ Surgical wounds (e.g. postoperative wounds left to heal by secondary intention)
- ▶ Wound dehiscence
- ▶ Skin abrasions and lacerations
- ▶ Superficial and partial-thickness burns



**Figure 3.**  
KytoCel ribbon dressing for use in cavity wounds.

**Table 1: KytoCel dressing range**

Sizes available
5x5cm
10x10cm
15x15cm
4x10cm
4x20cm
4x30cm
2.5x45cm

- ▶ Exudate absorption in oncology wounds (e.g. fungating cutaneous tumours, cutaneous metastases and Kaposi's sarcomas).

### Contraindications

KytoCel is not indicated for use for surgical implantation, third-degree burns or to control heavy bleeding. It should not be used on patients with known sensitivities to any of the components of chitosan, or who have had an allergic reaction to the dressing.

**'KytoCel is indicated for the management of moderate to heavily exuding acute and chronic wounds, and, due to its haemostatic properties may be used to control bleeding in superficial wounds'**

### Dressing application and removal

Select the most appropriate dressing size for the wound, allowing for a minimum of 0.5cm overlap. This enables the dressing to gel, thus maximising conformability. When using KytoCel ribbon dressings in deep cavity wounds, insert the ribbon in one piece and leave at least 2.5cm outside the wound for ease of removal.

The dressing should be cut, folded or layered to fit the wound. If the wound is deep, do not pack the dressing tightly, but loosely fill in order to allow room for the dressing to expand.

All wounds should be covered and secured with an appropriate secondary dressing.

KytoCel can remain *in situ* up to seven days, depending on the patient's situation, the condition of the periwound skin and the volume and consistency of exudate being produced. It is important to change the dressing before it reaches maximum capacity. To help removal, saturate the dressing with sterile saline or sterile water to allow the dressing to gel and assist with one-piece removal.

The following cases show how KytoCel gelling fibre dressings supported wound healing in a timely manner and minimised potential complications, such as delayed healing, maceration and infection.

### CASE REPORT ONE

Mr R was a 58-year-old farmer who presented with a skin tear of the right lower shin, with evidence of soil debris within the wound bed, following a trauma injury at work. Mr R's skin tear was classified by the tissue viability nurse as category 3 (Stephen-Haynes, 2012). He was a known insulin-dependent diabetic with neuropathy and high blood glucose, and had a history of venous leg ulceration and cellulitis.

Following an initial assessment in the A&E department, Mr R was referred to the tissue viability service for advice and management.

At presentation to the tissue viability team, the skin tear measured 8.2cm long and 2.2cm wide (Figure 4). The wound was actively bleeding, with associated erythema.

Following full assessment of Mr R and the skin tear, it was decided by the tissue viability team to change Mr R's dressing to KytoCel gelling fibre dressing, due to its exudate management, haemostatic and antimicrobial properties (Figure 5). His previous history of leg ulceration necessitated the need for compression therapy to promote venous return and reduce oedema. Following pain assessment, analgesia was provided.

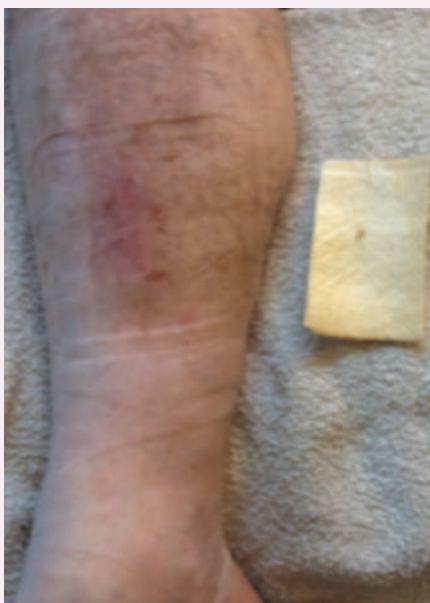
At review three days later, the wound bed appeared clean and



**Figure 4.**  
*Mr R's skin tear on 31 October, 2013.*



**Figure 5.**  
*5 November, 2013, dressing in situ.*



**Figure 6.**  
*10 November, 2013, wound healed.*

healthy, with evidence of granulation and epithelial tissue. A review date was made, but no further dressings were required and maintenance compression hosiery was supplied.

### Discussion

The risk for patients with diabetes is well documented and, in particular, those patients with wounds may develop complications if not managed appropriately (Lioupis, 2005). Importantly, prevention, appropriate assessment and management and maintenance can prevent a skin tear from deteriorating into a leg ulcer (Thompson-McHale, 2013). Despite his high risk potential, Mr R's injury healed without needing systemic antibiotics within twelve days. Comprehensive holistic and wound assessment and early intervention with KytoCel enhanced the wound-healing recovery time and resulted in a positive outcome for this patient.

### CASE REPORT TWO

A 60-year-old patient sustained a trauma injury to his third finger while culling turkeys for the busy Christmas period. The sharp injury caused damage to the distal phalanx, incorporating the nail bed and distal phalanx joint (*Figures 7 and 8*). Initial first-aid treatment consisted of adhesive plasters, but he was unable to stop the bleeding and following attendance at his local surgery for medical advice, he was referred to the tissue viability team.

Following holistic and wound assessment, the tissue viability team decided to apply KytoCel to the wound bed as a primary dressing in order to aid haemostasis and reduce the risk of infection. A polymeric membrane finger dressing (PolyMem® Finger/Toe, Aspen Medical) was applied and secured by a micro pore tape (*Figure 8*). This approach maintained his hand function while providing protection, thereby allowing him to continue to work.

The patient was advised to keep the wound as clean as possible and his wife was shown and encouraged to change his dressing as required.



**Figure 7.**  
*Damage to the distal phalanx, incorporating the nail bed and distal phalanx joint at presentation (30 December, 2013).*



**Figure 8.**  
*As a primary dressing, KytoCel stopped the bleeding, allowed the patient to continue working and progressed the wound to healing (19 January, 2014).*

He was informed that he would probably lose the nail and arrangements were made for a follow-up appointment in the outpatient clinic a week later. At this stage, the wound had healed and the nail did not require evulsion.

### Discussion

Maintaining activities of daily living and being able to continue working were essential for this patient. Exudate management, periwound protection and reducing the risk of infection while maintaining full function and dexterity were primary concerns.

## CONCLUSION

By incorporating a natural polysaccharide extracted from crab shells — chitosan — which is then heavily processed through fibre extrusion, felt conversion and packaging, an acylated chitosan wound dressing for the care of chronic wounds has been produced. Its properties, such as non-toxicity, non-irritation, non-immunogenicity, degradability and good bio-compatibility establish its place as a multifunctional, biointeractive advanced dressing from a natural source.

Due to its high absorbency and moisture retention, KytoCel gelling fibre dressing can absorb excess exudate, maintain a moist environment for wound healing, accelerate wound healing and promote skin regeneration. Its gelling action on contact with exudate, makes it easy to remove and helps to prevent the dressing from adhering to the wound bed, thus promoting patient comfort and reducing pain at dressing change and providing a unique alternative to other dressings currently available. **JCN**

*Conflict of interest: The cases were carried out independently of Aspen Medical by the second author in her honorary role as Tissue Viability Nurse Specialist for East Kent University Hospitals, NHS Foundation Trust.*

## REFERENCES

- Coulter A, Collins A (2011) Making shared decision-making a reality: No decision about me without me. King's Fund, London. Available online at: [www.kingsfund.org.uk/document.rm?id=9190](http://www.kingsfund.org.uk/document.rm?id=9190)
- Cutting K, White R (2005) Criteria for identifying wound infection. *Ostomy Wound Manage* 51(1): 28–34
- Dai T, Tanaka M, Huang YY, Hamblin R (2011) Chitosan preparations for wounds and burns: antimicrobial and wound-healing effects. *Expert Rev Anti Infect Ther* 9(7): 857–79
- Department of Health (2009) Transforming Community Services: Ambition, Action, Achievement. Transforming services for acute care closer to home. Available online at: [http://www.dh.gov.uk/prod\\_consum\\_dh/groups/dh\\_digitalassets/documents/digitalasset/dh\\_102198.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_102198.pdf)
- Department of Health (2010a) Equity and Excellence: Liberating the NHS. DH, London. Available online at: [www.dh.gov.uk/prod\\_consum\\_dh/groups/dh\\_digitalassets/@dh/@en/@ps/documents/digitalasset/dh\\_118610.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/documents/digitalasset/dh_118610.pdf)
- Department of Health (2010b) QIPP: Quality, Innovation, Productivity and Prevention. DH, London. Available online at: [www.dh.gov.uk/en/Healthcare/Qualityandproductivity/index.htm](http://www.dh.gov.uk/en/Healthcare/Qualityandproductivity/index.htm)
- Department of Health (2011) Innovation, Health and ealth: accelerating adoption and diffusion in the NHS. DH, London. Available online at: [http://www.dh.gov.uk/prod\\_consum\\_dh/groups/dh\\_digitalassets/documents/digitalasset/dh\\_134597.pdf](http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_134597.pdf)
- Dowsett C (2008) Exudate management: a patient-centred approach. *J Wound Care* 17(6): 249–52
- European Wound Management Association (2013) Antimicrobials and non-healing wounds: Evidence, controversies and suggestions. *J Wound Care* 22(suppl 5): S1–S89. Available online at: [http://ewma.org/fileadmin/user\\_upload/EWMA/pdf/EWMA\\_Projects/Antimicrobial/JWC\\_EWMA\\_supplement\\_NO\\_CROPS.pdf](http://ewma.org/fileadmin/user_upload/EWMA/pdf/EWMA_Projects/Antimicrobial/JWC_EWMA_supplement_NO_CROPS.pdf)
- Foda NH, El-laithy HM, Tadros MI (2007) Implantable biodegradable sponges: effect of interpolymer complex formation of chitosan with gelatin on the release behavior of tramadol hydrochloride. *Drug Dev Ind Pharm* 33(1): 7–17
- International Consensus. Optimising Wellbeing in people living with a wound. An expert working group review. London: Wounds International, 2012. available online at: <http://www.woundsinternational.com>
- Jayakumar R, Prabakaran M, Sudheesh Kumar PT, Nair SV, et al (2011) Biomaterials based on chitin and chitosan in wound dressing applications. *Biotechnol Adv* 29: 322–337
- Jones J, Barraud J (2013) Superabsorbent dressings — have we reached maximum capacity? *J Community Nurs* 27(4): 66–72
- Khor E, Lim LY (2003) Implantable applications of chitin and chitosan. *Biomaterials* 24(13): 2339–49
- Lee DW, Lim H, Chong HN, Shim WS (2009) Advances in chitosan material and its hybrid derivatives: a review. *Open Biomaterial J* 1: 10–20
- Li Q, Dunn ET, Grandmaison EW, Goosen MFA (1992) Applications and properties of chitosan. *J Bioact Compat Polym* 7: 370–97
- Lioupis C, (2005) Effects of diabetes mellitus on wound healing: an update. *J Wound Care* 14(2): 84–6
- Lu G, Ling K, Zhao P, et al (2010) A novel in situ-formed hydrogel wound dressing by the photocross-linking of a chitosan derivative. *Wound Rep Regen* 18: 70–9
- Mezzana P (2008) Clinical efficacy of a new chitin nanofibrils-based gel in wound healing. *Acta Chir Plast* 50(3): 81–4
- Niekraszewicz A (2005) Chitosan medical dressings. *Fibres and Textiles in Eastern Europe* 13, 6(54): 16–18
- Ousey K, Stephenson J, Barrett S, et al (2013) Wound care in five English NHS Trusts: results of a survey. *Wounds UK* 9(4): 20–8
- Payne RL, Martin ML (1993) Defining and classifying skin tears: need for a common language. *Ostomy Wound Manage* 39(5): 16–26
- Stephen-Haynes J (2012) Skin tears: achieving positive clinical and financial outcomes. *Br J Community Nurs* 17(Sup 1): S6–S16
- Stephen-Haynes J, Bielby A, Searle R (2011) Putting patients first: Reducing the human and economic costs of wounds through the appropriate use of advanced wound management products. *Wounds UK* 7(3): 47–55
- Thompson-McHale S (2013) Skin tears: assessment, prevention, classification and management. *Nurs Residential Care* 15(11): 710–14
- Wounds UK (2013) Best Practice Statement. The use of topical antimicrobial agents in wound management. 3rd edn. Wounds UK, London

## KEY POINTS

- Maintaining a moist wound healing environment and preventing and managing infection are essential to best practice in wound care.
- Healthcare professionals need to select products that are acceptable to their patients.
- The development of KytoCel, an advanced wound dressing, from a natural source, has resulted in a multifunctional, biointeractive dressing.