Effectiveness of multipurpose liquid polyurethane foamed bandage (LOKUS) in wound area reduction

Polyurethane foam dressings have shown potential in the treatment of acute and chronic wounds due to their unique biomechanical properties. The LOKUS polyurethane foam is a liquid foam dressing previously shown in a small single-centre study to demonstrate high absorptive capability and reliable adhesion to the wound surface. This case series describes the usage of the LOKUS liquid polyurethane foam bandage in the treatment of 47 patients with chronic wounds attending the Wound Clinic of Kuala Lumpur General Hospital over a period of 3 months.

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Wound exudate is a normal part of the response to injury and helps to promote wound healing via several mechanisms (Moore and Strapp, 2015). However, excessive exudate production has been shown to impede wound healing, impact on quality of life (QoL), and poses a challenge for management of hard-to-heal wounds (World Union of Wound Healing Society [WUWHS], 2019). Management of wound exudate, along with debridement and managing bacterial balance, is a vital component of wound bed preparation, which is defined as removal of barriers to healing in a chronic wound (Schultz et al, 2003). The management of exudate in wound bed preparation is represented by the principle of moisture balance (M) in the TIME framework, along with tissue management (T), inflammation and infection control (I), and epithelial advancement (E) (Sibbald et al, 2003). Achieving ideal moisture balance in a wound environment depends on selection of the appropriate dressing material, with occlusive or semi-occlusive dressings typically used for dry wound eschar, and absorptive dressings such as foam used for exudative wounds (Halim et al, 2012).

Conventional foam dressings show limited efficacy in treating highly exudative wounds as their top layers do not allow passage of exudate, leading to leakage and increased risk of infection once the dressing is saturated. Hence, polyurethane dressings were developed as a means to surmount this limitation, with a microporous top layer preventing bacterial penetration but allowing for passage of exudate, and a macroporous sponge-like sublayer promoting effective drainage of fluids from the wound and adherence to the wound surface. (Hinrichs et al, 1992)

Variables governing the efficacy of a polyurethane foam dressing are the pore size of the wound contact layer and cell size of the absorptive layer. These are crucial as small pore sizes are vital to prevent removal of fibroblasts and keratin on dressing change, hence delaying wound healing (Levina et al, 2001), while cell sizes influence the capillary forces acting on wound exudate and hence affect absorptive ability (Thomas, 2010). Moisture vapour transmission rate (MVTR) provides a measure of the ability of a dressing to regulate moisture balance, with a low MVTR representing poor exudate drainage, and a high MVTR indicating excessive fluid loss leading to desiccation (Wu et al, 1995). A comparative study on the commercial polyurethane foam dressing Medifoam N linked its relatively small pore/cell size to increased fluid absorption and retention, improved tissue ingrowth into the wound interface, a favourable MVTR, and a reduced frequency for dressing changes, in comparison with eleven other commercially available polyurethane foam

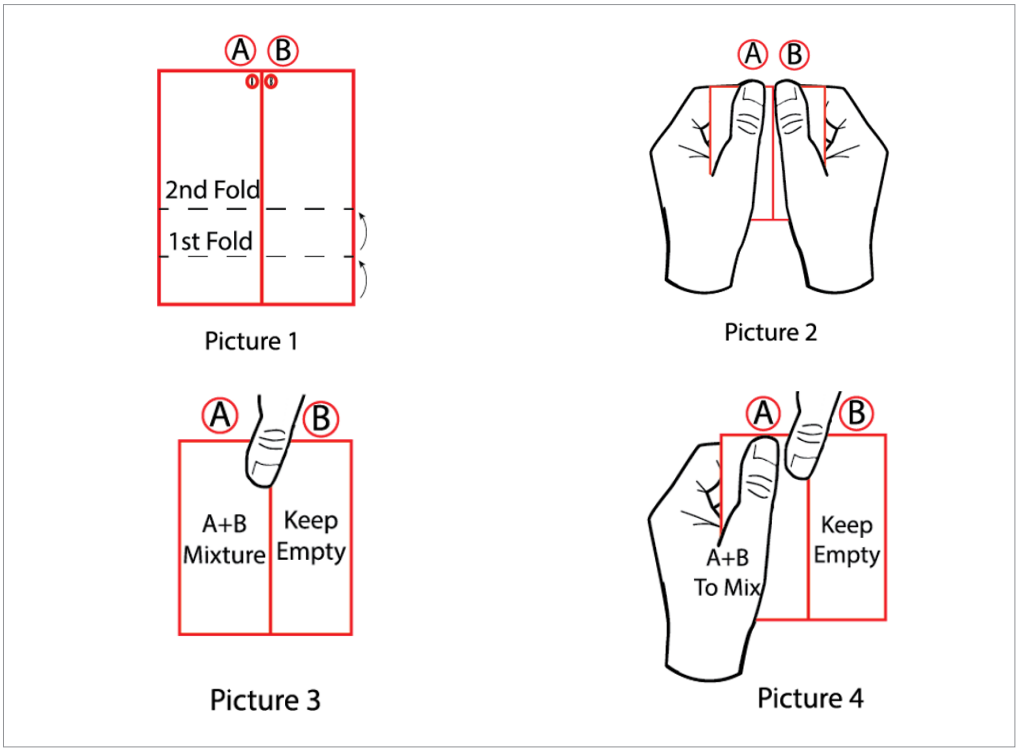


Figure 1: **Steps in preparing the LOKUS foam dressing**

dressings (Lee et al, 2016).

LOKUS is a self-expanding polyurethane foam dressing first developed in the Medical Military Institute of the Federal Security Department in Nizhny Novgorod, Russia, in the late twentieth century. A 2013 Russian study of 74 patients treated with the LOKUS foam dressing reported favourable outcomes owing to its high absorption capacity and reliable adhesion to the wound surface (Smirnov et al, 2013). Here, we describe the case study of 47 patients with hard-to-heal wounds treated with the LOKUS polyurethane foam in the Wound Clinic of Kuala Lumpur General Hospital, Kuala Lumpur, Malaysia.

Methods

Patients with wounds were recruited from the Wound Clinic, Hospital Kuala Lumpur and their progress followed for a period of three months. Patients wounds were assessed using the TIME concept and measurements (length x width in cms) were determined from serial digital photographs that were taken of the wound.

This study was not randomised and patients who presented at the clinic with any wound type could be recruited. These are walk-in patients who visited the outpatient clinic from Mondays to Fridays with wounds of varying aetiology including venous leg ulcers (VLU), diabetic foot ulcers (DFU), pressure ulcers (PU), post-traumatic wounds, surgical wounds and wounds associated with malignancy. The LOKUS foam was used as a secondary dressing for the wounds where the primary contact layer varies from hydrogel, silver gel and honey-based gel. Patients who developed allergic reactions to the LOKUS foam dressing were removed from this study. Written consent for this treatment was obtained from all patients.

If it was determined that the wound was suitability for application of the LOKUS foam dressing, the wound was cleaned and prepared. The foam dressing was prepared according to the manufacturer's instructions (Figure 1): by folding the twin sachet and rupturing the partitions between the two compartments. The liquid phase of the dressing was mixed for 25–30 seconds until the sachet was palpably warm and bulging, following which the liquid foam was applied directly onto the wound from the centre outward to the edges while capturing 2–3cm of dry skin surrounding the wound. Wound dimensions were measured with a ruler and photographed (with written consent) before application of the dressing, as well as 3 months after treatment with the LOKUS polyurethane foam. The patients visited the clinic for dressing changes twice a week. The amount of exudate was visually assessed based on the state of the dressing and maceration of the wound.

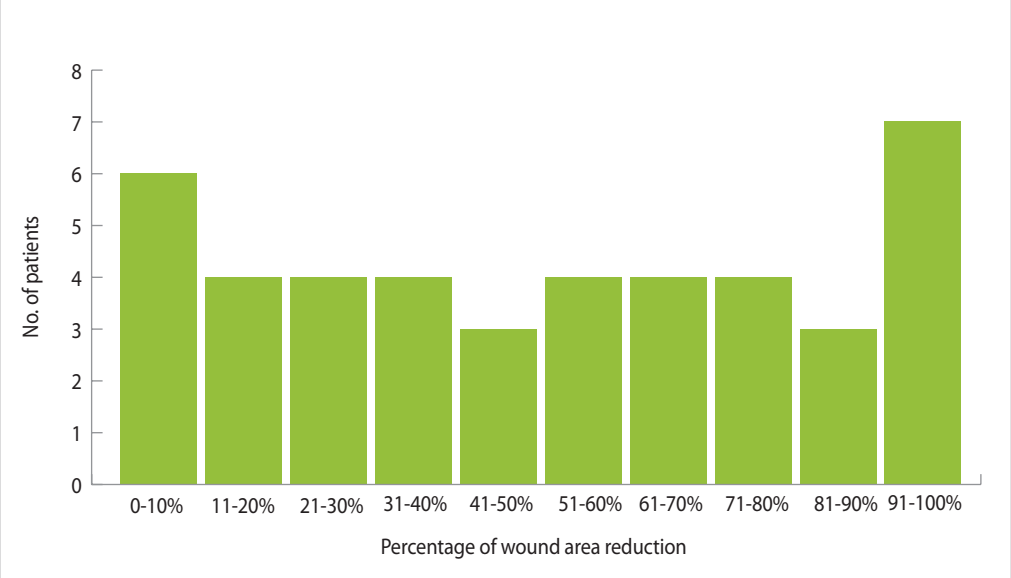


Figure 2: Percentage of wound area reduction after initiation of LOKUS foam dressing starting from August 2020 until January 2021

Results

A total of 47 patients with hard-to-heal wounds were recruited from the Wound Clinic, Hospital Kuala Lumpur.

Approximately 20% (10 patients) of the 47 patients studied achieved more than 80% reduction in wound area (measured as length x width in cms (Figure 2). In addition, almost half of the patients attained had at least a 50% decrease in wound area following application of the LOKUS dressing at the end of the 3 month study.

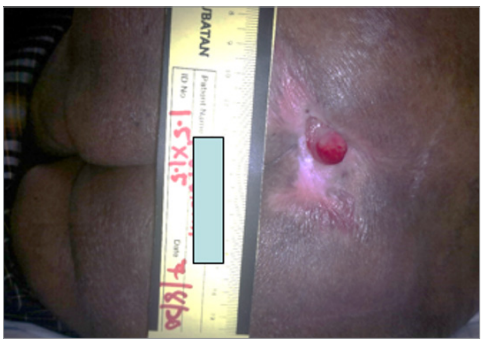
There were two patients who did not complete the study, one passed away during the period of study due to an underlying malignancy, while another patient was lost due to follow-up from our clinic. These patients were excluded from our data collection.

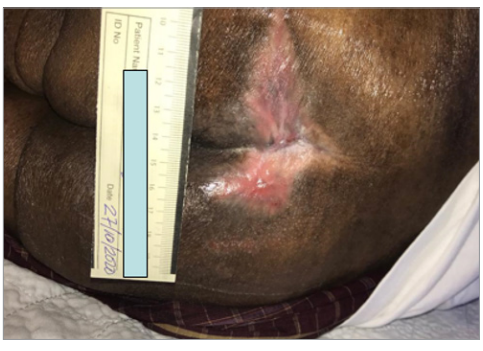
There was also a reduction to almost near zero of wound exudate and bioburden based on continuous wound observation each time a patient came to the clinic for dressing changes, as reflected in the pictures taken pre-and post-treatment with the LOKUS dressing.

There were four study patients who experienced a noticeable increase in wound diameter, despite treatment with the LOKUS dressing. These results were later found to be attributable to specific patient factors. In one patient a DFU lacked offloading footwear and the other three patients did not comply with compression bandaging for their venous leg ulceration. Although disappointing, this patient subset demonstrates that the LOKUS dressing is

Case 1

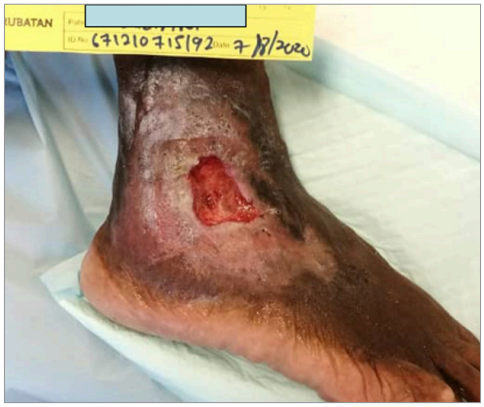
- A 62-year-old Malay gentleman presented with a category IV sacral PU that developed after prolonged hospitalisation for an appendix tumour in March 2020.
- Treatment with the LOKUS polyurethane dressing over the wound for 2 months led to complete wound healing, good epithelialisation and optimal skin condition.

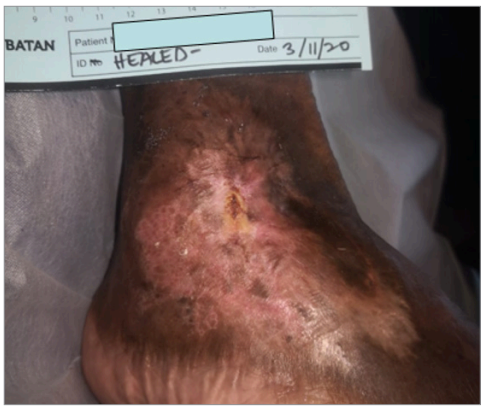




Case 2

- A 54-year-old Malay woman with a history of chronic venous insufficiency presented with a chronic non-healing venous ulcer over the medial malleolus of her left foot.
- Complete wound healing was achieved after treatment with the LOKUS polyurethane dressing over three months, supplemented with a compression bandage.





best used synergistically with optimal foot care and management of patient factors, and that best results may be seen after underlying factors are corrected or mitigated.

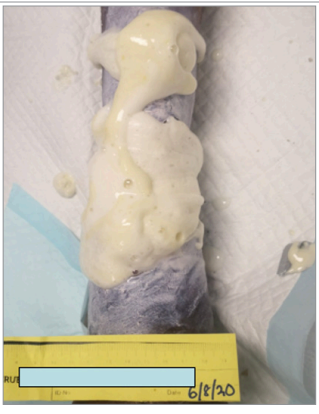
Of the patients treated with the LOKUS polyurethane foam dressing, 90% (42 patients) experienced reductions in wound size as well as the amount of wound exudate over a two month period. In particular, wound size reduction of 90% or more was achieved in 5 of our patients, with two of these patients reporting complete healing of their wounds. These 5 cases with 90% wound reduction are discussed in detail below.

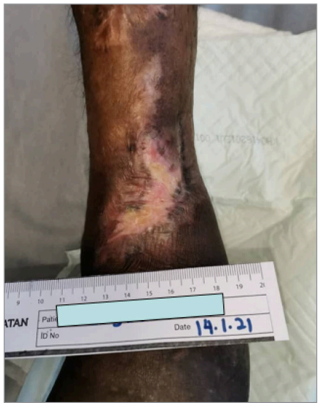
Case 1

A 62-year-old Malay gentleman presented with a category IV sacral PU following prolonged hospitalisation for an appendix tumour in March 2020. The PU had developed over the five months before presenting to our clinic, where regular dressing changes were done at the local health clinic using normal saline dressing. Upon presentation, the wound measured 1.5 (length) x 1.5 cm (width). SuprasorbC, Biofill A, and stimulant gel were used interchangeably as a primary dressing and LOKUS polyurethane as a secondary dressing. It was held *in situ* using adhesive tape. Following two months

Case 3

- A 45-year-old Indian lady with long-standing diabetes mellitus and peripheral vascular disease presented to the wound clinic with a chronic VLU on her right leg with a necrotic patch.
- There was local pain and tenderness over the wound site, systemic symptoms of fever and lethargy indicated ongoing infection, which was treated with antibiotics.
- Following resolution of the infection, complete healing of the ulcer was achieved following five months with the LOKUS polyurethane foam, with good granulation, epithelialisation, and minimal skin surface irregularities at the site of the ulcer.



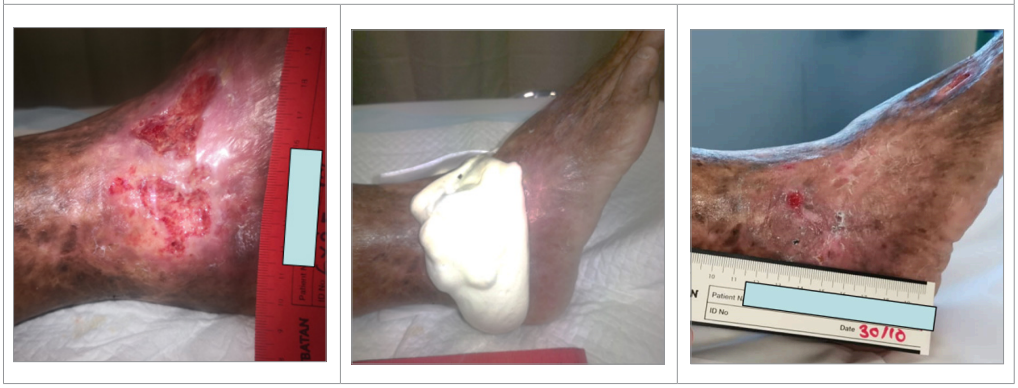


Case 4

- A 54-year-old Indian lady with underlying diabetes mellitus and hypertension presented to the wound clinic with a sloughy, right DFU with an exposed tendon.
- The wound initially started as a pressure blister that ruptured and failed to progress to healing despite regular gauze dressings at her local clinic.
- Treatment with the LOKUS dressing over six months resulted in a 95% reduction in wound bed size, with good epithelialisation and healthy wound edges. A significant decrease in wound exudate was also noted.

Case 5

- A 63-year-old Malay female with underlying diabetes mellitus and hypertension presented with a cluster of multiple chronic venous ulcers over the lateral malleolus of her right foot.
- Following treatment with the LOKUS dressing over two months, the multiple venous ulcers reduced to a single wound area with almost a 99% wound area reduction. Good granulation tissue and epithelialisation and nil exudate were noted at the end of treatment.



of treatment with the LOKUS polyurethane dressing over the wound, complete wound healing was achieved with good epithelialisation and optimal skin condition observed. No pressure relief treatments were given to patient.

Case 2

A 54-year-old Malay woman with a history of chronic venous insufficiency presented with a chronic non-healing venous ulcer over the medial malleolus of the left foot. The wound measured 2.5cm (length) x 4.5cm (width) for almost three months before presentation. Regular dressing changes were done using Biofil AB and melolin. During the study, stimulant gel was used as a primary dressing and LOKUS polyurethane as a secondary dressing. It was held *in situ* by applying a compression bandage over the dressing. Complete wound healing was achieved after treatment with the LOKUS polyurethane dressing over 3 months. This was supplemented with a compression bandage.

Case 3

A 45-year-old Indian lady with long-standing diabetes mellitus and peripheral vascular disease presented to the wound clinic with a chronic VLU on her right leg with a necrotic patch. The wound measured 7.5cm (length) x5cm (width) and had been present two months prior to the study. Regular dressing changes were done using Biofil, Espuma and Calmoseptine. During the study, a stimulant

gel was used as the primary dressing and LOKUS polyurethane as a secondary dressing. It was held *in situ* using a crepe bandage over the dressing. In addition to local pain and tenderness over the wound site, systemic symptoms of fever and lethargy indicated ongoing infection, which was treated with Tablet Unasyn 375mg BD for one week. Following resolution of the infection, complete healing of the ulcer was achieved following 5 months treatment with the LOKUS polyurethane foam, with good granulation, epithelialisation , and minimal skin surface irregularities at the site of the ulcer.

Case 4

A 54-year-old Indian lady with underlying diabetes mellitus and hypertension presented to the wound clinic on August 2020 with a sloughy, right DFU with an exposed tendon measuring 9cm (length) x 9cm (width). The wound initially started as a pressure blister that ruptured and failed to progress to healing despite regular gauze dressings applied at her local clinic for four months prior to presentation. During the study, a stimulant gel was used as a primary dressing and LOKUS polyurethane as a secondary dressing. It was held *in situ* using a crepe bandage over the dressing. Following treatment with the LOKUS dressing over six months, a 95% reduction in wound bed size was achieved with good epithelialisation and healthy wound edges observed. A significant decrease in wound exudate was also noted.

Case 5

A 63-year-old Malay female with underlying diabetes mellitus and hypertension presented with a cluster of multiple chronic venous ulcers over the lateral malleolus of her right foot. The ulcers had been present for more than 2 months prior to the study and had been treated with a regular dressing such as wound kreme, calmoseptin and melolin. The wound initially started as a non-healing blister and then became ulcerated; the wound measured 6cm (length) x 3.5cm (width). During the study, Biofil AB was used as the primary dressing and the LOKUS polyurethane as a secondary dressing. It was held *in situ* using a crepe bandage over the dressing. After over two months of treatment with the LOKUS dressing, the ulcers had reduced to a single wound area with almost a 99% wound area reduction. Good granulation tissue and epithelialisation was observed and there was no signs of exudate by the end of treatment.

Discussion

Polyurethane foam dressings have drawn interest due to their potential superiority to conventional dressings, particularly in regulating moisture balance and providing favourable conditions for wound healing. In an early *in vivo* study, the polyurethane dressing Lyofoam was shown to accelerate wound healing by two to three times compared with dry cotton gauze (Winter, 1975). In addition to preventing dehydration, bullae formation and bacterial penetration, polyurethane dressings may also enhance wound tissue infiltration and cell growth at the wound interface due to their porous structure (Doillon, 1987).

In a study in Spain using a Polyurethane Foam Multilayer Dressing the mean number of dressing changes was reduced from 3.14±1.77 changes per week to 1.66±0.87 (p<0.001 (Tiscar-González et al, 2021). Furthermore, the wound area significantly reduced from 9.90±19.62 cm^2 to 7.10±24.33cm^2 with a 58.7% reduction in weekly costs using the intervention (Tiscar-González et al, 2021). Patients and providers agreed that their satisfaction with wound care improved (Tiscar-González et al, 2021).

Here we report a reduction in wound size and wound exudate for patients treated with the LOKUS polyurethane foam dressing in our clinic. An important advantage of the liquid phase of the LOKUS foam lies in its ability to easily conform to wound shapes and adhere to healthy skin around the wound (Smirnov et al, 2013). This has implications for the treatment of VLUs and DFUs that are often irregular in shape and contour and selecting the best shaped solid polyurethane foam dressing to these wounds can be difficult. The relatively user-friendly application of the LOKUS foam dressing and its ability to fit irregular wound borders creates immense potential for the treatment of DFUs, which incur a significant disease burden in Malaysia's diabetic population. Further *in vivo* and *in vitro* studies into the properties of the LOKUS polyurethane dressing are required, particularly on the influence of pore/cell size on MVTR and absorptive/retentive capacity for fluid, its effects on the wound interface, and biomechanical protection of the wound area.

Conclusion

Although the sample population of our single-centre case study is small, we are confident that these encouraging results could serve to drive further investigation into the biomechanics of the LOKUS polyurethane foam, as well as its clinical application in the

treatment of acute and chronic wounds.

The LOKUS polyurethane foam is conformable as a secondary dressing where it works as a wound interface and allows absorption of exudate. Exudate management is a very important aspect of wound bed preparation. The LOKUS polyurethane foam can be used to help manage levels of exudate, which in turn allows for the reduction in wound size, healing and complete closure.

References

World Union of Wound Healing Societies (2019) Consensus Document. Wound exudate: effective assessment and management. *Wounds International*, London

Doillon CJ (1987) Porous collagen sponge wound dressings: in vivo and in vitro studies. *J Biomater Appl* 2(4):562–78. https://doi.org/10.1177/088532828700200404

Halim AS, Khoo TL, Saad AZM (2012) Wound bed preparation from a clinical perspective. *Indian J Plast Surg* 45(2):193–202. https://doi.org/10.4103/0970-0358.101277

Hinrichs WL, Lommen EJ, Wildevuur CR, Feijen J (1992) Fabrication and characterization of an asymmetric polyurethane membrane for use as a wound dressing. *J Appl Biomater* 3(4):287–303. https://doi.org/https://doi.org/10.1002/jab.770030408

Lee SM, Park IK, Kim YS et al (2016) Physical, morphological, and wound healing properties of a polyurethane foam-film dressing. *Biomater Res* 20(1):15. https://doi.org/10.1186/s40824-016-0063-5

Levina EM, Kharitonova MA, Rovensky YA, Vasiliev JM (2001) Cytoskeletal control of fibroblast length: experiments with linear strips of substrate. *J Cell Sci* 114(23):4335–341

Moore Z, Strapp H (2015) Managing the problem of excess exudate. Br J Nurs 24(Sup15):S12–S17. https://doi.org/10.12968/bjon.2015.24.Sup15.S12

Schultz GS, Sibbald RG, Falanga V et al (2003). Wound bed preparation: a systematic approach to wound management. Wound Repair Regen 11:Suppl 1:S1–28. https://doi.org/10.1046/j.1524-475x.11.s2.1.x

Sibbald R, Orsted H, Schultz G et al (2003) Preparing the wound BED 2003: Focus on infection and inflammation. *Ostomy Wound Manage* 49(11):23–51

Smirnov SV, Shakhlamov MV, Litinsky MA et al (2013) Polyurethane foam covering for wounds, burns and ulcers. *Wound Medicine* 2–3:6–8. https://doi.org/https://doi.org/10.1016/j.wndm.2013.10.001

Thomas S (2010) Laboratory findings on the exudate-handling capabilities of cavity foam and foam-film dressings. *J Wound Care* 19(5):192–99. https://doi.org/10.12968/jowc.2010.19.5.48049

Tiscar-González V, Menor-Rodríguez MJ, Rabadán-Sainz C et al (2021) Clinical and economic impact of wound care using a polyurethane foam multilayer Dressing. *Adv Skin Wound Care* 34(1)23–30. https://doi.org/10.1097/01.asw.0000722744.20511.71

Winter GD (1975) Epidermal wound healing under a new polyurethane foam dressing (LYOFOAM). *Plast Reconstr Surg* 56(5): 531–7. https://doi.org/10.1097/00006534-197511000-00009

Wu P, Fisher AC, Foo PP et al (1995) *In vitro* assessment of water vapor transmission of wound dressings. *Biomaterials* 16(3):171–75. https://doi.org/10.1016/0142-9612(95)92114-L