Polymeric Membrane Dressings for Topical Wound Management of Patients With Infected Wounds in a Challenging Environment: A Protocol With 3 Case Examples

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Abstract

Patients with acute wounds often delay seeking medical assistance until an incapacitating infection has developed. When such patients come for help at a remote Christian clinic in northern Ghana, West Africa, the goals of care are to resolve and prevent a return of infection, decrease pain, enable an immediate return to normal activities, and facilitate healing. Because the local protocol of care, Edinburgh University Solution of Lime (EUSOL)-soaked gauze, did not meet these goals, the author tried using a variety of donated wound dressing regimens. Ultimately, polymeric membrane dressings (PMDs) were observed to meet patient care needs while also reducing clinic staff time and resources, and a PMD protocol of care was developed. Three (3) representative patients who presented with acute wounds and infection are described: a 20-year-old man with a hand abscess, a 16-year-old boy with a malleolus wound, and an approximately 20-year-old woman with an injection abscess, all otherwise relatively healthy, albeit undernourished. All 3 patients received oral antibiotics, their wounds were initially cleansed and debrided, and an appropriate configuration of either regular or silver-containing PMDs was applied to all exposed wound surfaces. Dressing changes were scheduled based upon the personalized plan of care. In all 3 patients, the pain-relieving properties of PMDs allowed resumption of activities within 1 day of initiating treatment, the dressings' continuous wound cleansing system kept the wounds clean and free of infection despite the challenging environment, and the wounds healed steadily. Managing infected acute wounds with PMDs through complete wound closure was time efficient for clinic staff and met all 4 major patient goals of care. Randomized, controlled studies to compare wound and quality of life outcomes in patients whose infected wounds are managed with PMDs compared with those whose wounds are managed with other advanced dressings are warranted.

Keywords: case study, underdeveloped nation, wound infection, pain, wound healing

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Potential Conflicts of Interest: Although Dr. Benskin was an unsupported clinic volunteer when she developed this protocol, she is now an employee of Ferris Mfg. Corp, Fort Worth, TX.

Acute wounds that initially are not managed appropriately often become infected, particularly in areas with warm climates and unsanitary living conditions.[1–3] A cross-sectional epidemiological study[1] of 2 impoverished areas in the tropics (N = 6917) found the most common cause (51.61%) of a chronic wound was a mismanaged acute traumatic wound. In this author's experience, patients suffering from infected acute wounds who are accustomed to being healthy are often reluctant to modify their activities of daily living to accommodate optimal wound healing conditions. Clinicians treating patients with infected acute wounds in a real-world setting may find it difficult to meet the conflicting goals of patients whose main priority of returning to work causes them to engage in activities that can delay wound healing or even exacerbate their injury.

At the rural Christian clinic in a remote area of northern Ghana, West Africa where the author worked for 5 years, the challenge was to meet patient goals by restoring functional quality of life while using minimal clinic resources. These patients often are subsistence farmers or laborers whose families would go hungry if they were unable to continue working. The environment in this area of Ghana is harsh:

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The Clinic's PMD Wound Management Protocol

1. Thorough initial wound cleansing/debriding, ONLY at initial presentation
2. Fill any deep wound areas with PMD cavity filler/rope
3. PMDs applied to all exposed wound surfaces and over any PMD filler/rope
4. Secure well with bedsheet strips, tape, and/or stretch gauze
5. Change daily until wound exudate levels diminish, then as needed
6. No rinsing at dressing changes, simply replace PMDs and filler/rope
7. Treat the whole patient: provide oral pain medications, vitamins and nutritional counseling, prayer, and antibiotics as needed.

Figure 1. The clinic's protocol for wound management using polymeric membrane dressings (PMDs).

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Key Points

- The author describes wound care experiences in a rural clinic in a remote area of northern Ghana.
- Because obtaining care for an acute or chronic wound often is delayed until the wound becomes very painful or impairs function, wounds frequently are infected on presentation to the clinic.
- To illustrate the effectiveness of the protocol of care developed to facilitate healing and early return to a fully functional status, the author presents 3 case reports of patients whose infected wounds healed with oral antibiotics and the use of polymeric membrane dressings.

after an approximately 4-month rainy season, the remaining 8 months are mostly void of even dew, and when the arid Harmattan follows the rains, thick dust hangs in the air and permeates every crevice. In the humid hot season before the return of the rains, nightly low temperatures remain well over 80° F (27° C), with daily highs often soaring beyond 120° F (50° C). These year-round, incubator-like conditions contribute to a high rate of infections.[4]

Patients with acute wounds in this setting are in many ways similar to farm workers in developed countries; both groups often delay seeking medical assistance until they are unable to work.[5,6] Using a questionnaire, measurements of housing density and water quality, and skin examination of 1114 household members in 254 randomly selected households in 2 villages in Tanzania, Gibbs[6] found 80% of individuals with lacerations or puncture wounds on the lower legs did not seek treatment. Thierry and Snipes[5] reviewed 393 open-ended injury narratives from a database of face-to-face interviews by trained bilingual interviewers that included a nationally representative sampling of farmworkers (the National Agricultural Workers Survey) and compared the narratives with demographic surveys from the National Institute of Occupational Safety and Health's supplemental injury module for hired crop workers using qualitative (grounded theory) and quantitative (descriptive discriminant analysis) research methods. Farm workers in the United States based their decision to seek medical treatment for an injury almost entirely upon whether they could continue working. In neither study was economic status of the injured person a major influence in the decision to seek medical assistance.

During negotiations among Ghanaian clinic nurses and patients to create realistic treatment plans for acute wound patients, patients and caregivers consistently agreed upon 4 primary goals: establishing a clean wound bed and keeping it clean, decreasing persistent wound pain, facilitating the immediate resumption of normal activities, and promoting quick healing.

The Setting. Very few health care professionals choose to work in remote areas of western Africa, including persons interested in wound care. Patients at the clinic in which the author volunteered benefited from the collaboration of 2 BSN Ghana State Registered Nurses (SRNs) who were committed to improving wound management in this harsh setting: a Ghanaian with decades of tropical wound management experience and the author, an American with extensive formal continuing education training in wound care. The wound protocols described in this study were refined by these 2 health care professionals over the years they worked together.

The clinic gained a reputation for success in wound care, frequently serving patients with wounds who traveled from distant areas. These patients often stayed with distant relatives in villages closer to the clinic than their homes, allowing them to walk only 1 to 10 miles to reach the clinic for their dressing changes. On a typical day, the author, sometimes with an assistant, would dress wounds for as many as 20 patients before seeing the medical patients, who came to the clinic with illnesses such as malaria, dysentery, and pneumonia. This high volume of patients (~600/year) with a wide variety of acute and chronic wounds allowed the author to quickly discover what was successful (and what was not) in this environment.

Wound infections are an especially common complication in warm unsanitary environments such as the one surrounding the clinic.[1,4] Keeping wounds clean was extremely challenging in this setting. The clinic staff had very limited resources in terms of both supplies and personnel. However, a wide variety of advanced dressings and basic wound care supplies are donated to the clinic, primarily by individuals in the US. As such, cost, marketing, reimbursement, and formulary listings had no bearing on advanced wound dressing evaluations. The author trialed supplies, methodically using them as she had learned in her wound management course. She had some initial success with closing wounds using copious quantities of triple antibiotic ointment and gauze. However, this method of wound management was slow and painful, and the patients were unable to resume their usual work activities for weeks.

Most of the other donated advanced wound products did not perform as well in keeping wounds clean as the local standard of care preferred by the author's Ghanaian colleague (Edinburgh University Solution of Lime [EUSOL] soaked gauze) with one exception. Through trial and error, various configurations of polymeric membrane dressings (PMDs) (PolyMem®, Ferris Mfg. Corp, Fort Worth, TX), consistently were found to keep wounds far cleaner than any of the many other available products. Also, while EUSOL prevents infection, it is cytotoxic, which slows healing.[2] When PMDs were used, a healthy deep pink wound bed with granulation buds along the edges often was established by the next daily dressing change. Wounds closed much more quickly with PMDs than with either EUSOL or thick antibiotic ointment, and patients found PMDs so comfortable they could usually return to work and to their usual roles in their families during treatment. In contrast with other modern dressing choices, infection did not regain a foothold in the wound bed after initial cleaning/debriding.

The author subsequently learned her positive experience when comparing PMDs with the other dressings was not unique; a distinction between PMDs and other advanced dressings has been reported in more than 30 studies[7–40] and numerous conference poster presentations (see Table 1 for an annotated list of references and Table 2 for a breakdown of posters by topic, available online).

Mode of action. A prospective crossover study[7] and case series[8,10,12] have shown PMDs continuously cleanse wounds. Overviews, literature reviews, and case series[18,19,32,34,35] support that PMDs release a nontoxic surfactant cleanser[41] to break the chemical bounds between the wound bed and adhering slough, dirt, or other substances that may impair healing. As shown in case series and reviews,[15,19,32,35,36,38] the hydrophilic (water-loving) components of PMDs (the substrate and glycerol, a bacteriostatic simple sugar) pull nutrient-filled, enzyme-rich fluid from the body into the wound bed, enhancing both healing and autolytic debridement. A case series,[8] a literature review,[35] and a randomized, controlled trial (RCT)[13] found the loosened undesirable substances are drawn into the superabsorbent and substrate of the PMD along with excess fluid. Manual cleansing or rinsing can increase pain, and may slow healing by cooling, or can even damage fragile new granulation tissue.[42-44] The literature shows these common interventions are rarely necessary when PMDs are used.[8,13,18,31,34,35] Because PMDs are nonadherent, reviews and case reports[8,12,14,18,31,36] show the dressing change process is quick and easy.

Pain. Several RCTs and numerous clinical reviews and best practice documents[10,11,14,15,18,21–24,27,29–31,33–35] support that PMDs relieve pain (see Table 1). The relief of persistent wound pain provided by PMDs goes beyond that obtained by simple occlusion; an RCT[24] in 72 rats comparing PMDs with other dressings show PMDs placed on either intact skin or on wounded areas of the body subdue and focus the nociceptor response, as measured by a significant (P <0.05) decrease in spinal cord Fos expression at Laminae I through VI, inclusive, a significantly (P <0.05) smaller area of spread of inflammatory cells at the wounding site, and significantly (P <0.0001) decreased withdrawal latency. In humans, this ability of PMDs to subdue and focus the nociceptor response, as demonstrated in 2 RCTs[10,22] and literature reviews and case series,[14,23,30,34] explains the observed decrease in secondary inflammation and resultant decrease in pain, bruising, and edema. Patients with acute and chronic wounds treated at author's clinic usually experienced such dramatic decreased pain and inflammation when PMDs were initiated their normal activities, such as walking and farming, could be resumed as soon as they stepped out of the clinic.

Also, case series[30,32,34] have shown this decreased secondary inflammation can help increase circulation, which facilitates healing. When wounds were managed with PMDs in the clinic in Ghana, granulation buds usually were observed at the first dressing change.

Additional benefits. Unlike conventional foam dressings, in reviews and case series[15,19,32,35,36] PMDs have been shown to be appropriate for use over structures that must be protected from desiccation, such as tendon and bone, as well as in heavily exudating wounds. This is because in addition to directly introducing glycerol onto all wound surfaces, the hydrophylic components of PMDs pull fluid from the body and redistribute it to dry areas of the wound bed while absorbing exudate from areas that are overly moist, as shown in reviews and case series.[19,30,31,36,38] Reviews and case series[8,19,35,36,38] also have found that because of this ability to optimize wound moisture and continuous wound cleansing, PMDs are indicated for use on every wound type at every stage of healing.

The combination of keeping the wounds clean, decreasing pain, and brisk healing impressed the entire clinic staff so much that the author solicited donations of PMDs directly from the manufacturer, who provided enough PMDs for the clinic to use PMDs on virtually all patients with wounds.

Clinic use. Using PMDs on hundreds of patients with wounds for more than 16 months demonstrated to the author and clinic staff that these dressings were able to meet or exceed all of the expectations of the clinic's patients with wounds while decreasing the clinician time required for appropriate wound management. Using PMDs also resulted in a decrease in supplies needed for wound care, partly because when PMDs were used, wounds rarely needed to be rinsed during dressing changes.

Highlights from Published Independent Studies

In response to successful use of PMDs on a variety of wound types, physicians Kim et al[10] performed 3 prospective studies comparing PMDs with petrolatum gauze dressings: 1 with 15 rabbits (using contralateral sides) followed by 2 RCTs with human patients who had either second-degree

burns (n = 44) or split-thickness skin graft donor sites (n = 28). The researchers found wounds in all 3 studies closed significantly faster with PMDs (P <0.05 for epithelization in the animal study and P <0.01 for healing time in both human patient groups). Both of the clinical trials with human patients demonstrated significantly decreased pain (P <0.01) and improved patient comfort (P <0.01) scores with PMDs.

Yastrub,[13] a nurse practitioner, conducted a RCT comparing PMDs with conventional moist dressings (antibiotic ointment and gauze) on 44 Stage II pressure ulcer patients in a long-term care facility.[13] Using the Pressure Ulcer Scale for Healing (PUSH) tool, the author found significantly improved healing scores (P <0.001) in the PMD group.

In a historical cohort comparison trial, Weissman et al[30] compared PMDs to previous usual practice (an antibiotic plus steroid ointment) on patients with facial burns in Israel. Patients whose burns were managed with PMDs reepithelialized more quickly (6.5 days versus 8.5 days) and experienced less wound site pain (average 2.6 versus 4.7 on a scale of 0–10), as well as a complete lack of dressing change pain. No manual cleansing was needed at dressing changes when PMDs were used, a benefit of using PMDs that saved nurse time and dramatically decreased overall costs. The researchers also observed that typically facial burn patients suffer additional damage due to secondary (neurogenic) inflammation, but when PMDs were used on patients with facial burns, the area of inflammation did not extend beyond the actual area of the burn.[30]

A case series[32] of 6 consecutive patients was conducted with a focus on the wound cleansing ability of PMDs in patients with diabetic foot ulcers complicated by both deep abscesses and osteomyelitis. The silver rope configuration of PMDs was inserted into the deep cavities, with adjunct topical oxygen therapy provided during twice a week dressing changes. Despite poorly controlled diabetes (HbA1c >9 throughout treatment) in 2 patients and significant arterial insufficiency (ankle-brachial indices of 0.57 and 0.61) in at least 2 patients, the wounds of all 6 patients healed completely and did not recur. The authors concluded surgical interventions can be safely replaced by the continuous wound cleansing actions of PMDs in at least some patients who have both deep diabetic foot ulcer abscesses and osteomyelitis.

The use of PMDs was evaluated in a prospective case series[31] of 20 consecutive patients with head and neck cancer, including patient reported pain-, sleep-, and free-text diaries, as well as objective measures and subjective reports from nursing staff. Compared with the facility's standard treatment for radiation-induced skin damage (topical aqueous cream for initial burns with the addition of paraffin gauze when moist desquamation occurs), the use of PMDs decreased both moist and dry skin desquamation and decreased the sensation of burning for all 20 study patients, indicating PMDs were able to balance moisture and decrease inflammation. PMDs were easy for nursing staff to adapt to meet the patients' individual needs. When PMDs were used, patients reported a cooling sensation on the skin, dramatically decreased pain in the radiation affected area, decreased dressing change pain, increased comfort, and increased sleep; nurses confirmed these findings and documented improved skin healing. Family members performed many of the dressing changes, and manual cleansing was eliminated for all but 6 of the patients by week 3. The facility changed its protocol for radiation-induced skin reactions as a result of this study, replacing the previous treatment method with PMDs.

The results of these studies are congruent with the current author's experiences with PMDs. The purpose of reporting these cases is to provide examples of how the Ghanaian clinic's PMD wound management protocol met the needs of patients with infected acute wounds in a challenging environment.

Protocol

The clinic's usual PMD wound management protocol (see Figure 1) was followed for at least 900 patients (dozens with infected acute wounds), including the 3 example patients presented. After initial cleansing and/or debriding, PMD cavity filler (with or without silver, depending upon dressing availability and the patient's perceived immune status) was inserted into any undermined areas, and then standard PMDs (with or without silver) were applied to the exposed surfaces of each wound and over any cavity filler. PMDs were changed daily at first, with intervals increasing up to a week as exudate levels diminished. Initial daily dressing changes were important because often the wound produces a large amount of exudate for the first few days of PMD use.[18,19,35] As granulation tissue increased and the wounds became cleaner, exudate levels decreased so the patient could make less frequent clinic visits without jeopardizing healing. The optimal time for the patient to return to the clinic was easier to anticipate with experience.

At their initial clinic visit, all patients with wounds also routinely received oral pain medications (usually over-the-counter dosages of a nonsteroidal anti-inflammatory), vitamins, extensive nutritional teaching, prayer, and antibiotics as appropriate in addition to direct topical wound care. Although many of the patients suffered from chronic protein deficits, it was not possible for this small clinic to provide nutritional supplements in this setting. Due to the need for all of these patients to continue working during treatment, PMDs often were covered with porous protective outer materials such as bedsheet strips or, occasionally, stretch gauze. The bedsheet strips could provide nonelastic compression.

The patients described here were chosen as representatives of the larger group because on the first day of their wound management each had provided written informed consent for their images and data to be used by the author, allowing the data to be prospective, and because their photographic and written documentation was relatively complete. All 3 patients

Figure 2. a) January 19: initial appearance of wound before and after incision and drainage. The wound was flushed thoroughly and packed with iodoform gauze; b) January 22: the wound remains infected and too painful to allow the patient to work. Clinicians began inserting silver polymeric membrane dressing (PMD) cavity filler to clean out the large area of circumferential undermining the previous day; c) January 26: silver PMD cavity filler continuously cleansed and absorbed exudate; d) February 20: successful resolution of infection and undermining in 1 month.

were young and comparatively healthy other than their debilitating infected acute wounds (patients 2 and 3 showed some protein malnutrition, as was typical for individuals of low social status in this culture). None of the example patients sought treatment beyond self-care for their wounds until pain from severe infection motivated them to request care.

Example Patients

Patient 1. An approximately 30-year-old, otherwise healthy man punctured his hand with a stick. Because it was not extremely painful at the time, he did not stop to wash the wound. Two (2) weeks later, a painful abscess had developed. He came to the clinic when the pain became unbearable (10 on a 0 – 10 scale) (see Figure 2a).

His pain was so excruciating it was difficult for him to allow caregivers to touch his hand. Lancing the abscess released a large quantity of yellow and brown fluid. After thoroughly flushing the cavity with normal saline to remove clots of exudate, iodoform gauze (NuGauze, Johnson and Johnson, Princeton, NJ) packing strips were inserted into the undermined area. The dorsum of the hand then was covered with gauze and wrapped with stretch gauze. Ceftriaxone (2 g) was given intramuscularly (IM), and the patient went home with 5 days of oral cephalexin (500 mg, twice daily) and oral ibuprofen+caffeine to be taken as needed for pain. Because he reported having felt feverish, the patient also was presumptively treated for malaria, which was endemic in the area.

Dressings were changed daily by the author. The skin over the central wound area had been stretched so much by the pressure from the abscess it was not viable. This skin was left to demarcate and separated on its own at the first dressing change, leaving a 5 cm x 6 cm x 1 cm deep malodorous open wound with ~2 cm of undermining in all directions. By the second dressing change (day 3), it was clear the use of iodoform gauze packing strips in the large cavity wound could not provide satisfactory results for this patient. Despite antibiotics and pain medications, the extreme persistent wound pain prevented sleep, the quantity of purulent malodorous exudate indicated the infection was not resolving, and the undermining was expanding (see Figure 2b).

Treatment was changed to PMDs on day 3. Layers of silver PMD cavity filler were laid flat in the large area of undermining between the skin and the exposed muscle. Silver PMD cavity filler was used due to the risk of infection spreading up the tendons and down into the bones of the hand. Silver PMDs pull microbes into contact with silver locked into the dressings, making them safer than other silver dressings.[37,39] The flexibility of PMDs was advantageous in this mobile area of the body. The patient was encouraged to move his hand to avoid contractures. One day later (day 4), the decreased pain and inflammation provided by the PMDs allowed the man to grip his hoe so he could farm again. A standard (not silver) PMD was used as the secondary dressing, and stretch gauze was used to protect the dressings from dirt. Dressings were changed daily.

On day 5 (the second dressing change with PMDs), the patient laughed and joked with the clinic staff about his previous pain, which was now a 0 on the 0 – 10 scale. The silver PMD cavity filler painlessly pulled the purulent malodorous exudate from the wound bed, even in the deepest areas of undermining (see Figure 2c). Within a week, the silver PMD cavity filler, when removed, was saturated with serous exudate only, indicating the infection was resolved. At that point, rather than using cavity filler, an extra-thick PMD (without silver) was placed over the entire open wound on the dorsum of the hand, and a pressure dressing was applied to allow the undermining to seal shut. Subsequent dressing changes consisted of replacing the PMD, then wrapping the hand to keep the dressing clean as the patient farmed. Dressing changes decreased from daily to twice a week when the cavity filler was no longer used. The PMDs continued to keep the wound

Figure 3. a) September 1: after initial limited sharp debridement, tendons were covered by only a very thin layer of muscle tissue, no granulation, and 30% slough; b) September 4: granulation tissue is migrating from the wound edges 3 days after initiation of treatment; c) September 30: the wound continued to fill in until it completely closed.

bed clean without any rinsing at dressing changes. Granulation tissue formed rapidly. The patient remained virtually pain-free with full range of motion. At 4 weeks, a standard thickness, 2.5 cm x 2.5 cm bordered cloth adhesive PMD was used to dress the now small, superficial wound (see Figure 2d). The patient was dismissed from the clinic <6 weeks after the use of PMDs on his wound was initiated.

Patient 2. A 16-year-old, mildly protein-malnourished boy (nutrition status determined by midarm circumference measurement) cut the area of his medial malleolus while hoeing. He applied local leaves to the wound, which burned the tissue as they decomposed and may have contributed to his malodorous infection. He reported through a series of interpreters (his dialect was not spoken beyond his remote village) that his pain level was so high it completely prevented him from being able to farm. Because he needed to be able to farm again to help support his family, his wound management needed to diminish his persistent wound pain and to dress the wound in a way that would not inhibit his ankle movement. Ceftriaxone (1 g) IM and oral amoxycillin provided for 7 days diminished the wound odor and purulent drainage, but initial sharp debridement and wound cleansing was incomplete because of concern the boy's tendons, visible through a thin layer of muscle tissue, could be damaged by aggressive debridement techniques (see Figure 3a).

The avascular ankle wound measured 7 cm x 5 cm x 0.8 cm deep with 30% adherent yellow slough and moderate serosanguineous drainage when standard PMDs were initiated. Three (3) thin pieces of PMD cavity filler were cut to fit into the deep grooves between the visible tendons. The entire wound area then was covered with an improvised extra-thick dressing made of a PMD cavity filler covered with a standard-thickness PMD (at the time this boy was being cared for at the clinic, the clinic had a temporary shortage of extra-thick PMDs) (see Figure 3b). Due to the distance the boy had to travel to get to the clinic (more than 30 miles), the plan of care was for every-other-day dressing changes with extra-thick PMDs to absorb the wound exudate. However, flooding of local rivers led to his erratic clinic attendance. The wound developed thick green adherent slough when he was unable to come for dressing changes. This was managed with cleansing using a cotton-tipped applicator and rinsing with saline to remove the loose dirt and slough before applying a fresh extra-thick PMD. Otherwise, dressing changes consisted of removing the saturated PMD and applying a new one, then wrapping the ankle area with a bedsheet strip bandage or stretch gauze to protect it from dirt during farming. Saline rinses were added when visible dirt from farming found its way under the dressings.

By day 3, the wound bed was already much cleaner with noticeably decreased size and depth at the first dressing change. On the second dressing change (day 7, because flooding prevented the boy from coming to the clinic sooner) the wound was 0.5 cm deep and the wound filler was no longer needed. At this second dressing change, through a series of interpreters the boy stated he had been completely pain free, even during farming. Oral antibiotics were restarted because it was anticipated that sporadic flooding would continue to prevent him from attending the clinic regularly. Granulation tissue filled in the wound bed steadily. After 4 weeks of PMDs, despite erratic clinic attendance and soaking the wound in muddy water for prolonged periods of time, the wound was 94% smaller, measuring 4.9 cm x 3.4 cm x 0.1 cm deep (see Figure 3c).

Patient 3. A relatively healthy young woman (uncertain of her age but probably ~20 years old based upon her appearance, her memory of historical events, and her circumstances in life) presented with a large injection abscess on her left buttock. Injection abscesses are a common complication of medical care provided by uneducated itinerant pharmaceutical sellers. These entrepreneurial individuals travel from village to village with a box containing a jumble of tablets, capsules, tonics, and injectables strapped to the back of a bicycle. They are often illiterate and rarely have sanitary equipment.

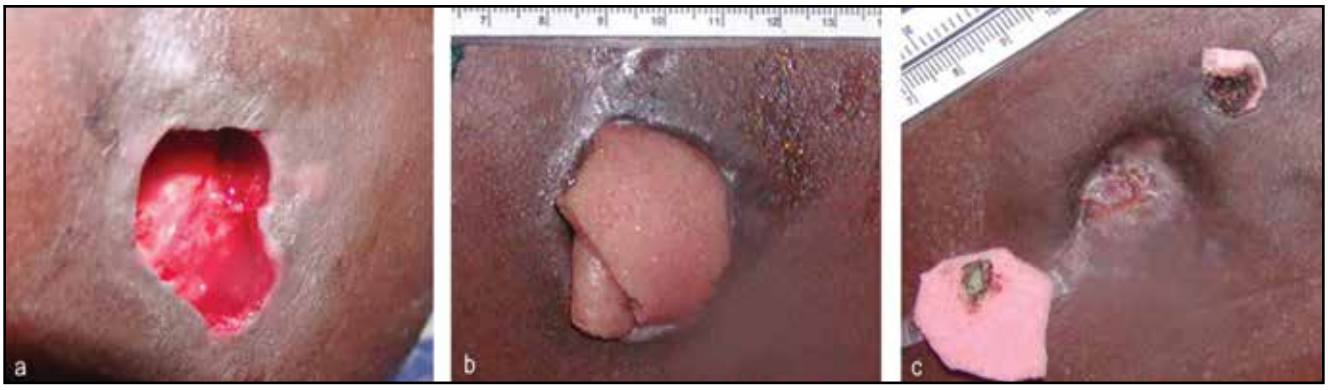

Figure 4. a) June 9: foul exudate was thoroughly cleaned out, leaving exposed muscle tissue. Polymeric membrane dressing (PMD) cavity filler was used to fill the entire undermined area; b) June 21: 2 layers of cavity filler were needed now. Note the flexibility of the PMD cavity filler being removed; c) July 27: despite the patient's protein deficit, the undermining resolved and the wound decreased to 0.5-cm deep.

The woman's occupation as the driver in a fufu pounding operation (food preparation) required her to be able to move vigorously while sitting on a low stool. Due to cultural taboos, young women are not permitted to eat meat, eggs, or peanuts, and milk products were unavailable where she lived; this patient's protein intake was quite limited. The skin covering the abscess was not viable and sloughed off, exposing an approximately 5-cm diameter, 2-cm deep cavity with a base of muscle tissue (see Figure 4a). After the wound was irrigated with saline to remove the foul exudate, 4 layers of standard PMD cavity filler were torn to fit and placed one on top of another to gently fill the entire undermined area. A standard PMD was placed over the wound bed and window-pane taped in place.

The young woman received oral antibiotics and ibuprofen (400 mg) as needed for her reported pain. Dressings were changed daily at first, with decreasing frequency as the cavity filled in and less exudate was produced. Because the surfactant from the PMDs continuously loosened wound debris and the superabsorbent pulled the contaminants and the excess exudate into and onto the dressings, no manual wound cleansing or even rinsing was required at dressing changes. The abscess granulated quickly and filled in; only 2 layers of PMD cavity filler were needed by treatment day 12 (see Figure 4b).

The patient walked several miles to and from the clinic for dressing changes during the entire course of her wound management. This young woman was able to return to her work on the day PMD wound management began with her pain controlled by pain medication and PMDs. The flexibility of the PMD cavity filler allowed her to sit and to move freely as her wound healed (see Figure 4c). The abscess closed completely in 8 weeks.

Discussion

The patient cases presented demonstrate how infected acute wounds successfully healed with antibiotics and PMDs without return of the infection. Most patients with wounds treated at the clinic, including all 3 of the example patients, walked many miles for dressing changes. Due to the decreased wound pain following application of PMDs, patients were able to resume their normal daily activities, including strenuous manual labor, by their second dressing change at the latest. The flexibility of the dressings and the substantial reduction of their wound pain and inflammation increased patient quality of life by allowing the patients to resume the usual roles in their families. Wound bed cleansing during dressings changes was necessary only when dirt or debris was able to migrate under the dressings during farming. Eliminating routine wound cleansing at dressing changes significantly decreased the staff time and supplies needed to care for these patients. These attributes have been repeatedly cited in the literature described herein.

Managing infected acute wounds with PMDs also allowed care providers to meet all identified patient goals: freedom from infection, quick healing, significant pain relief, and minimal inconvenience. The clinic also benefitted when PMDs were used because patients required far fewer clinic resources for complete wound closure.

Limitations

The author and the clinic staff successfully managed hundreds of wounds, ranging from minor tropical leg ulcers to life-threatening diabetic foot abscesses, with this PMD protocol. For the final 16 months of the author's tenure at the clinic (after PMDs were donated in sufficient quantities to prevent serious shortages), it was rare for a wound to be managed with any other dressing type. However, due to time constraints, detailed documentation was gathered for only a small fraction of these patients, and many suffered from chronic rather than acute wounds. Therefore, no rigorous scientific study was performed, and only 3 patients with infected acute wounds are described here in detail. The external validity of this study is also limited by the unique location and observational nature of case studies.

Conclusion

Three (3) example cases illustrated how the use of PMDs met all goals of care for patients with infected acute wounds. The results seen in the Ghanaian clinic — specifically, the observations that PMDs clean wounds, keep them clean, decrease both dressing change and persistent wound pain, facilitate the immediate resumption of normal activities, and increase healing rates — have been documented in other studies. This suggests results observed may apply to patients in less challenging locales. RCTs to compare wound outcomes and quality of life of patients whose wounds are managed with PMDs compared with those whose wounds are managed with other advanced modalities are warranted. ■

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References

1. Gupta N, Gupta SK, Shukla VK, Singh SP. An Indian community-based epidemiological study of wounds. *J Wound Care*. 2004;13(8):323–325.
2. Oluwatosin OM. Wound care practices and challenges in Nigeria. *Adv Skin Wound Care*. 2007;20(7):375–378.
3. Belcher DW, Afoakwa SN, Osei-Tutu E, Wurapa FK, Osei L. Endemic pyoderma in Ghana: a survey in rural villages. *Trans R Soc Trop Med Hyg.* 1977;71(3):204–209.
4. Taplin D, Lansdell L, Allen AM, Rodriguez R, Cortes A. Prevalence of *streptococcal pyoderma* in relation to climate and hygiene. *Lancet Lond Engl.* 1973;1(7802):501–503.
5. Thierry AD, Snipes SA. Why do farmworkers delay treatment after debilitating injuries? Thematic analysis explains if, when, and why farmworkers were treated for injuries. *Am J Ind Med*. 2015;58(2):178–192.
6. Gibbs S. Skin disease and socioeconomic conditions in rural Africa: Tanzania. *Int J Dermatol*. 1996;35(9):633–639.
7. Blackman JD, Senseng D, Quinn L, Mazzone T. Clinical evaluation of a semipermeable polymeric membrane dressing for the treatment of chronic diabetic foot ulcers. *Diabetes Care*. 1994;17(4):322–325.
8. Fowler E, Papen JC. Clinical evaluation of a polymeric membrane dressing in the treatment of dermal ulcers. *Ostomy Wound Manage.* 1991;35:35–44.
9. Carr RD, Lalagos DE. Clinical evaluation of a polymeric membrane dressing in the treatment of pressure ulcers. *Decubitus.* 1990;3(3):38–42.
10. Kim YJ, Lee SW, Hong SH, Lee HK, Kim EK. The effects of PolyMem® on the wound healing. *J Korean Soc Plast Reconstr Surg*. 1999;26(6):1165–1172.
11. Campton-Johnston S, Wilson J, Ramundo JM. Treatment of painful lower extremity ulcers in a patient with sickle cell disease. *J Wound Ostomy Continence Nurs*. 1999;26(2):98–104.
12. Cimino P, Shipes E. Calciphylaxis in a patient with end-stage renal disease: Case situation. *J Wound Ostomy Continence Nurs.* 1999;26(3):161–166.
13. Yastrub DJ. Relationship between type of treatment and degree of wound healing among institutionalized geriatric patients with stage II pressure ulcers. *Care Manag J.* 2004;5(4):213–218.
14. Bolhuis J. Evidence-based skin tear protocol. *Long-Term Living Contin Care Prof.* 2008;57(6):48–52.
15. Rafter L, Oforka E. Standard versus polymeric membrane finger dressing and outcomes following pain diaries. *Wounds UK*. 2014;10(2):40–49.
16. Denyer J. Management of the infant with epidermolysis bullosa. *Infant.* 2009;5(6):185–188.
17. Denyer JE. Wound management for children with epidermolysis bullosa. *Dermatol Clin.* 2010;28(2):257–264.
18. Denyer JE, Pillay E. Best practice guidelines for skin and wound care in epidermolysis bullosa — International Consensus. 2012. Available at: www.woundsinternational.com/other-resources/view/best-practice-guidelines-for-skin-and-wound-care-in-epidermolysis-bullosa. Accessed March 30, 2015.
19. Denyer J, White R, Ousey K, Agathangelou C, HariKrishna R. PolyMem dressings made easy. *Wounds Int*. May 2015. Available at: www.woundsinternational.com/made-easys/view/polymem-dressings-made-easy. Accessed May 7, 2016.
20. Denyer J. Bathing in epidermolysis bullosa: benefit over trauma? *Wounds UK*. 2010;6(2):79–84.
21. Denyer J. Managing pain in children with epidermolysis bullosa. *Nurs Times*. 2012;108(29):21–23.
22. Hayden JK, Cole BJ. The effectiveness of a pain wrap compared to a standard dressing on the reduction of postoperative morbidity following routine knee arthroscopy: a prospective randomized single-blind study. *Orthopedics.* 2003;26(1):59–63; discussion 63.
23. Kahn AR, Sessions RW, Apasova EV. A superficial cutaneous dressing inhibits pain, inflammation and swelling in deep tissues. *Pain Med.* 2000;1(2):187.
24. Beitz AJ, Newman A, Kahn AR, Ruggles T, Eikmeier L. A polymeric membrane dressing with antinociceptive properties: analysis with a rodent model of stab wound secondary hyperalgesia. *J Pain Off J Am Pain Soc*. 2004;5(1):38–47.
25. Kammerlander G, Krammel M, Locherer E, Süss-Burghart A, Pichler H, Zweimüller P. PolyMem® QuadraFoam™ verkürzt die Heilungszeit bei sekundär heilenden und chronischen Wunden. *Schwest Pfleg*. 2008;47(11):1–4.
26. Stenius M. Holistic approach combined with PolyMem dressings healed a pressure wound grade 4 within 2.5 months. *Sår.* 2008;2008(3):28–29.
27. Langemo DK, Black J; National Pressure Ulcer Advisory Panel. Pressure ulcers in individuals receiving palliative care: a National Pressure Ulcer Advisory Panel white paper. *Adv Skin Wound Care.* 2010;23(2):59–72.
28. Minniti CP, Eckman J, Sebastiani P, Steinberg MH, Ballas SK. Leg ulcers in sickle cell disease. *Am J Hematol.* 2010;85(10):831–833.
29. Edwards J, Mason S. An evaluation of the use of PolyMem Silver in burn management. *J Community Nurs*. 2010;24(6):16–19.
30. Weissman O, Hundeshagen G, Harats M, et al. Custom-fit polymeric membrane dressing masks in the treatment of second degree facial burns. *Burns.* 2013;39(6):1316–1320.
31. Scott A. Polymeric membrane dressings for radiotherapy-induced skin damage. *Br J Nurs*. 2014;23(10):S24–S31.
32. Cahn A, Kleinman Y. A novel approach to the treatment of diabetic foot abscesses — a case series. *J Wound Care*. 2014;23(8):394–399.
33. Hegarty F, Wong M. Polymeric membrane dressing for radiotherapy-induced skin reactions. *Br J Nurs Mark Allen Publ.* 2014;23(suppl 20):S38–S46.
34. Davies SL, White RJ. Defining a holistic pain-relieving approach to wound care via a drug free polymeric membrane dressing. *J Wound Care.* 2011;20(5):250, 252, 254 passim.
35. Benskin LL. PolyMem® Wic® Silver® Rope: a multifunctional dressing for decreasing pain, swelling, and inflammation. *Adv Wound Care* (New Rochelle). 2012;1(1):44–47.
36. Dabiri G, Damstetter E, Phillips T. Choosing a wound dressing based on common wound characteristics. *Adv Wound Care.* 2016;5(1):32–41.
37. Burd A, Kwok CH, Hung SC, et al. A comparative study of the cytotoxicity of silver-based dressings in monolayer cell, tissue explant, and animal models. *Wound Repair Regen.* 2007;15(1):94–104.
38. Cutting KF, Vowden P, Wiegand C. Wound inflammation and the role of a multifunctional polymeric dressing. *Wounds Int J.* 2015;6(2). Available at: www.wintjournal.com/journal-content/view/wound-inflammation-and-the-role-of-a-multifunctional-polymeric-dressing. Accessed February 25, 2016.
39. Benskin LLL. Limitations of *in vitro* antimicrobial dressings study. *Burns.* 2016;42(6):1. doi:10.1016/j.burns.2016.01.034.
40. Rafter L, Oforka E. Trauma-free fingertip dressing changes. *Wounds UK.* 2013;9(1):96–100.
41. Rodeheaver GT, Kurtz L, Kircher BJ, Edlich RF. Pluronic F-68: a promising new skin wound cleanser. *Ann Emerg Med*. 1980;9(11):572–576.
42. Alferink M, de Zeeuw J, Sopoh G, et al. Pain associated with wound care treatment among Buruli ulcer patients from Ghana and Benin. *PLoS ONE.* 2015;10(6). doi:10.1371/journal.pone.0119926.
43. McGuiness W, Vella E, Harrison D. Influence of dressing changes on wound temperature. *J Wound Care.* 2004;13(9):383–385.
44. Large A, Heinbecker P. The effect of cooling on wound healing. *Ann Surg.* 1944;120(5):727-741.

Table 1: Clinical evaluations and reviews of polymeric membrane dressings (PMDs)

Author(s)/reference	Title (year of publication)	Type of study/evaluation or publication type/support	Sample size/patient and wound description	Study/evaluation purpose	Key findings pertaining to PMDs
Blackman JD, Senseng D, Quinn L, Mazzone T[7]	Clinical evaluation of a semipermeable PMD for the treatment of chronic diabetic foot ulcers (1994)	Prospective crossover study Supported by the manufacturer	N=18. Patients with chronic diabetic foot ulcers (DFUs) (>20 weeks) excluding Wagner Stage III, hard eschar, Charcot joints, and those pending vascular surgery Authors note patients did not offload as recommended	Compare PMDs to wet-to-dry saline dressings on chronic DFUs Measured % size reduction	Ulcer size in PMD group (11 patients) was reduced to average 35% of baseline in 2 months; ulcer size in conventional group (7 patients) increased to 105% of baseline in 2 months (P <0.03) 2 patients from each group withdrew from the study due to ulcer progression to grade III Remaining 5 patients in conventional group crossed over to PMD at 2 months; crossover DFUs decreased to average 35% of baseline with PMDs in 2 months more (P <0.02) By 6 months with PMDs, 8 of the original 11 PMD patients' DFUs had closed, and 3 of the 5 crossover patients' DFUs had closed. The remaining 2 were lost to follow-up. Only 1 of the patients who used PMDs for a full 6 months did not achieve wound closure
Fowler E, Papen JC[8]	Clinical evaluation of a PMD in the treatment of dermal ulcers (1991)	Clinical evaluation (case series) by wound experts supported by educational grant from manufacturer	N=31 wounds (24 patients visiting outpatient wound clinic): 12 lower leg wound patients (10 full-thickness wounds, 2 partial), some of the wounds had been present for years; N= 12 patients (in skilled nursing facility [SNF]) with 19 nonhealing Stage II – Stage IV pressure ulcers (PUs), all chronically debilitated with neurological conditions	Open-enrollment, descriptive study to evaluate ability of film island PMDs to clean wound, improve color, improve periwound skin, decrease wound size and depth	Wounds improved in color, size, and depth; 94% of the wounds significantly improved or resolved SNF: 14 PUs closed, 3 improved >75%, 2 improved 25% – 49%, none failed to improve; outpatient: 5 leg wounds closed, 7 improved >75%, none failed to improve All 31 wounds converted to clean red wound beds "shortly" after beginning PMDs No sharp or mechanical debridement was needed, even on stringy necrotic debris Any edema and erythema resolved No maceration was noted even when dressings became saturated (felt like smooth gel) PMDs do not dissolve into or onto wound; need for cleansing upon removal was minimal Wear time was 12 hours to 3 days. Gelling minimized pain or discomfort upon removal
Carr RD, Lalagos DE[9]	Clinical evaluation of a PMD in the treatment of pressure ulcers (1990)	Clinical evaluation (case series): worst cases; chosen by nurses. Write-up by manufacturer	N= 18 PU patients: Stage I (3), Stage II (9), and Stage III (6) mostly chronic nonhealing (mean 144 days) PUs on 13 extremely debilitated patients (84% >72 years, mean weight 95.2 lb)	Evaluation on worst-case PUs: Can PMDs facilitate PU healing? Can PMDs help resolve worst-case PUs?	PUs closed more quickly with PMDs than published norms for PUs of each stage: 11/18 (61%) resolved, 6/18 improved, 0/18 the same or enlarged, 1/18 patient expired Nurses could tell visually when to change the dressings, little or no wound prep needed, less time needed for dressing changes, wound bed stayed moist and became clean Easy dressing application and removal, dressings removed intact atraumatically No secondary infections, maceration, odor, pain, or skin irritation Dressings stayed in place an average of 3.3 days The included wounds had not improved with previous modern moist dressings

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Kim YJ, Lee SW, Hong SH, Lee HK, Kim EK[10]	The effects of Poly-Mem® on wound healing (1999)	Comparative evaluation (RCT) No outside support	N= 72 patients: 44 with second-degree burns (PMD 24, petrolatum gauze 20); 28 with skin graft donor sites (PMD 14, petrolatum gauze 14)	Compared to petrolatum gauze, do PMDs improve healing, decrease pain, increase comfort? How many PMDs are needed in all?	Pain (0–3) was significantly lower after dressing with PMDs when compared with petrolatum gauze in both burn and donor site patients (0.5/3 vs 2.2/3, and 0.4/3 vs 1.9/3, P <0.01) Healing time was significantly faster with PMDs when compared with petrolatum gauze in burn and donor site patients (9.5 days vs 13.1 days and 9.9 days vs 12.1, P <0.01) Comfort (yes/no) was significantly higher with PMDs when compared with petrolatum gauze in both burn and donor site patients (92% yes versus 10% yes and 90% yes, vs 8%, P <0.01)
Campton-Johnston S, Wilson J, Ramundo JM[11]	Treatment of painful lower extremity ulcers in a patient with sickle cell disease (1999)	Case study No outside support	Single patient with sickle cell disease and painful lower extremity ulcers Many wound management choices were tried on this patient	Explore different wound management approaches for a difficult wound situation	Hydrasorb (Paul Hartmann, Ltd., UK) was used to cover Mesalt.(Mölnlycke Health Care, US) initially. However, it stuck to the wound bed PMDs were then used because they are absorbent PMDs did not stick to the wound bed, absorbed well, and “decreased the patient’s pain”
Cimino P, Shipes E[12]	Calciphylaxis in a patient with end-stage renal disease: case situation (1999)	Case study No outside support	Single patient with end-stage renal disease and calciphylaxis Many wound management choices were tried on this patient	Explore different wound management approaches for a difficult wound situation	Skin graft donor sites (SGDS) were managed with PMDs changed daily. PMDs were chosen because they “minimize the discomfort often associated with SGDS.” Dressing changes did not require rinsing or mechanical cleansing. All sites were healed at discharge except one small area
Yastrub DJ[13]	Relationship between type of treatment and degree of wound healing among institutionalized geriatric patients with Stage II PUs (2004)	RCT Supported by National Pressure Ulcer Advisory Panel (NPUAP) grant	N=44 long-term care patients with Stage II PUs	Do PMDs promote PU healing when compared with conventional dressings (thick antibiotic ointment and gauze)?	After 4 weeks, PMD group had improved mean healing scores versus ABX ointment (1.6087 versus 3.2381, P <0.001) 87% of PMD group and 65.2% of control group had improved Pressure Ulcer Healing Scale (PUSH) tool scores

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Bolhuis J[14]	Evidence-based skin tear protocol (2008)	Review of new skin tear protocol Article written by manufacturer	N= 450 facilities with 4 to 12 PMD and an equal number of control patients	Is the skin tear protocol with PMDs at its foundation superior to usual care for skin tears?	Data were incomplete (72 completed evaluation), partly because many facilities dropped out of the study prematurely to adopt PMDs facility-wide for skin tears. Documentation improved through the use of the protocol 88% adopted the new protocol and PMDs as their standard of care for skin tears Dressing changes were, on average, 90% faster to complete Healing times were increased 60% 76% fewer dressing changes were needed Episodes of bruising and swelling at the skin tear site were reduced Residents reported decreased procedural and persistent wound pain Total nurse time spent dressing a given skin tear decreased from 30 minutes to <4 minutes
Rafter L, Oforka E[15]	Standard versus PMD finger and outcomes following pain diaries (2014)	Cohort study No outside support for study. Manuscript supported by dressing distributer	N= 49 patients with finger injuries; first 19 qualifying patients received usual treatment (Mepitel, Mölnlycke Health Care UK; Melolin, Smith and Nephew, UK; and Tubinette, Mölnlycke Health Care UK); next 20 qualifying patients received PMD finger/toe dressings. Followed for 14 days	Comparing PMD finger/toe dressings with usual practice on pain, analgesia, sleep, quality of life, and nurses' perceptions	No significant differences between groups with respect to injury, sleep, or medication use Mean dressing wear time was 3.6 days in PMD group vs 2 days (control dressings fell off after one day in 8 patients) Patient average rating of dressings was 3.7 of 4 for PMDs and 2.84 of 4 for controls Cost of PMD is £2.50 versus £3.75 for control, and more dressings were needed, plus more time was spent at dressing changes, making PMDs more cost effective PMDs were comfortable and allowed the patients to function normally Nurses noted ease of application of PMDs (nonadherent) and no pain at dressing changes PMD was less painful at day 8 compared with controls, and patients could take showers
Rafter L, Oforka E[40]	Trauma-free fingertip dressing changes (2013)	Case series. No outside support for study. Manuscript supported by dressing distributer	N= 11 patients with fingertip injuries "randomly selected": 5 injuries were 1 week old at initiation of PMDs, 6 were acute wounds, all followed up in 7 days	Evaluate use of PMD finger/toe dressings	All 11 patients remarked on dressings conformability, allowing them to move their fingers despite their injuries. All rated dressings as extremely comfortable and application easy and pain-free. Relatives were able to apply dressing without assistance from clinicians, saving the patients the cost of attending clinic. All wounds healed well with satisfactory cosmetic results Patients wanted to be able to purchase the dressings themselves Nurses noted ease of use, nonadherence, lack of pain at dressing changes

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Author(s)/reference	Title (year of publication)	Type of study/evaluation or publication type/support	Sample size/patient and wound description	Study/evaluation purpose	Key findings pertaining to PMDs
Denyer J[16]	Management of the infant with epidermolysis bullosa (EB) (2009)	Overview No outside support	Overview based on experience with large numbers of EB patients	Describe best practices for caring for EB wounds in infants	Many products are discussed for various purposes. Bathing is not recommended until birth damage has healed in infants. Dressings are changed limb by limb in these patients. The author had recently discovered PMDs and recommended them for patients for whom bathing is not recommended or is refused (older children) because it contains a cleanser
Denyer JE[17]	Wound management for children with epidermolysis bullosa (2010)	Overview of best practices for managing EB No outside support	Overview based on experience with large numbers of EB patients	Describe best practices for caring for infants and children with EB, who have or are at high risk for wounds	Several dressings are recommended for children with EB. PMDs are listed as a unique dressing type and are recommended for chronic wounds in patients with junctional EB and critical colonization/infection, and for dystrophic EB where cleansing is required, as well as for all EB with infected and critically colonized wounds where biofilm is present PMDs are “stand-alone” dressings (no additional dressings are needed) Dressing change frequency is determined by personal choice, time, and level of exudate Infected or critical colonized wounds require more frequent dressing changes Use of PMDs increases exudate initially, requiring daily dressing changes during this time PMDs reduce bioburden for children who refuse wound cleansing and/or cannot bathe
Denyer JE, Pillay E[18]	Best practice guidelines for skin and wound care in epidermolysis bullosa. International consensus (2012)	Consensus guidelines for EB Supported by nonprofits and journals	Review /consensus for wound prevention and care of patients with EB	Review and summarize the current scientific evidence for prevention and care of wounds in EB patients	PMDs are recommended as the first choice dressing for most forms of EB and most of the complications of EB. Dressings should be changed when needed as determined by exudate level. Expect increased exudate when PMDs are first used May lead to a distinctive odor which is not a sign of infection PMDs are now the recommended dressing for neonates with extensive birth trauma with EB

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Denyer J, White R, Ousey K, Agathangelou C, HariKrishna R[19]	PolyMem dressings Made Easy (2015)	Review/overview Supported by dressing manufacturer	Review for wound prevention and care of patients with EB	Review and summarize PMD evidence and usage information.	PMD multifunctional dressings are presented as a solution to simplify wound care by stimulating the healing process, providing pain relief, continuously cleansing, and encouraging patients to be involved in their care, reducing costs while providing high-quality outcomes. “Dressing components work individually and synergistically…” Cleanser loosens bonds between the slough/fibrotic tissue and healthy granulation tissue. Moisturizer creates a moist environment and prevents sticking; draws fluid (including nutrition and growth factors) from deeper tissues into the wound bed to stimulate healing Superabsorbents draw wound exudate into the dressing and prevent it from being released back into the wound, which balances moisture and reduces maceration risk. Excess exudate evaporates through the semi-permeable membrane, regulating moisturewound temperature. The film also serves as a barrier to the ingress of external liquids The dressing swells to gently fill the contours of the wound PMDs ease inflammation and reduce associated bruising, swelling and pain Chart shows which PMD configuration is most appropriate for each wound Table shows seven clinical evaluations, case series, and trials and their key findings Case studies show reduction of pain, improvement of infected wounds, cleansing, reduced odor, improved sleep, nonadherence, ease of use, increased granulation, and reduced wound size using PMDs
Denyer J[20]	Bathing in epidermolysis bullosa: benefit over trauma? (2010)	Review/overview of best bathing practices for EB patients and case study No outside support	N=2 patients with EB	Describe best practices for caring for EB patients with regard to bathing	Several topical agents are recommended for these patients, including PMDs. In Case 2, PMDs led to a 43-cm reduction in a child with EB’s back wound over 8 weeks, and allowed the child to avoid bathing while on holiday for a week (he had 2 dressing changes with PMDs). Wound stayed clean without maceration, less hypergranulation, clear epithelialization at edges, and healthier periwound skin

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Denyer J[21]	Managing pain in children with epidermolysis bullosa (2012)	Review/overview of best pain practices for EB patients and case study No outside support	N=1 infant with EB	Describe best practices for caring for EB patients with regard to pain management	Pain is a problem for children with EB, particularly during dressing changes Case study patient is infant with EB whose dressings were adherent Paracetamol and morphine were inadequate for dressing change pain management. Switched to PMDs with thin hydrofiber between the toes to prevent fusion PMDs reduced parental stress: no adherence, precut dressings easy to apply, time to change dressings greatly reduced, analgesia need reduced with improved pain control Parents became more confident as baby's pain reduced and were able to hold him to feed and learned to do dressing changes themselves. Discharged home at age of 3 weeks
Hayden JK, Cole BJ[22]	The effectiveness of a pain wrap compared to a standard dressing on the reduction of postoperative morbidity following routine knee arthroscopy: a prospective randomized single-blind study (2003)	Randomized controlled, single blind, clinical study Supported by educational grant from manufacturer	N= 24 arthroscopic knee surgery patients (12 PMD group and 12 gauze control). Both groups had knees wrapped with an outer elastic bandage.	Determine the ability of PMDs to decrease postoperative pain, swelling, stiffness, and warmth over (mostly) intact skin	2 patients withdrew from the study because they did not believe the PMD was effective All dressings were removed at day 8 and blinded surgeon evaluated knees at ~day 10 PMD group had significantly lower leg temperature rise than control (1.1˚ F vs 3.9˚ F, *P*=0.02). PMD 10 day average pain rating was significantly lower than control (2.2 vs 4.6, *P*=0.03) Pain medication use (number of pills and number of days narcotic use) was not significantly different PMD group had less swelling and effusion (0.56 vs 1.08, *P*=0.22), not statistically significant Difference in stiffness between contralateral legs was also insignificant between groups (Researchers note: stiffness and swelling are more important indicators at 3 weeks postop) Conclusion: PMD wrap, at $100/patient, is cost effective and reduces inflammation and pain following routine arthroscopy. Suggest larger studies and comparison with cryotherapy

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Kahn AR, Sessions RW, Apasova EV[23]	A superficial cutaneous dressing inhibits pain, inflammation and swelling in deep tissues (2000)	Case series	N= 2 case study patients, 24 chronic lower back pain patients (cohort study), 1 chronic inflammatory skin disease patient, and 14 anesthetized rabbits using contralateral legs as controls in blinded RCT of enhanced PMDs in closed tissue injury	Determine if PMDs affect the nociceptor response over intact skin, decreasing pain, bruising, and edema	Patient who applied PMD to blunt injury developed visible bruising only in the area not covered by the dressing. Outline of dressing, which was not applied with pressure, visible 21 of 24 skeptical chronic lower back pain patients experienced significant improvement in pain when PMDs were applied over a 10-day period (cohort study) Patient with bilateral Morphea: full remission only on the side treated for 3 days with PMDs An arthroscopic knee patient whose knee was immediately wrapped in PMDs had complete immediate pain relief with no disability, swelling, bruising, or inflammation at the site. Rabbits: At 24 hours, swelling was 3.29/4 for controls and 0.71/4 in PMDs (P <0.001) At 48 hours, swelling was 2.36/4 for controls and 0.29/4 in PMDs (P <0.001) (11/14 were 0)
Kammerlander G, Krammel M, Locherer E, Süss-Burghart A, Pichler H, Zweimüller P[25]	PolyMem® Quadra-Foam™ verkürzt die Heilungszeit bei sekundär heilenden und chronischen Wunden (2008)	Case series Supported by manufacturer	N=58 patient (6 sites in 3 countries) case series of investigator selected challenging wounds	Determine if PMDs fill cavities, are both primary and secondary dressings, cleanse, promote healing, and are easy to use.	Sole application of PMDs clearly supports wound cleansing and granulation PMDs can be used alone without additional treatments or agents The cavity filler could be used in deep wounds without additional fillers Successful on a wide variety of common wound types: 50/58 wounds improved or closed 83% of patients had diabetes, kidney, or vascular conditions that interfere with healing Average wound area decreased from average 9.75 cm2 to 6.22 cm^2 22% of wounds closed completely, additional 64% showed significant improvement (86%) 12% of the wounds deteriorated and 2% stalled despite the use of PMDs (14%) 88% of clinicians scored ease of handling “good” or “excellent” — recommend further usage
Stenius M[26]	Holistic approach combined with PolyMem dressings healed a pressure wound Grade 4 within 2.5 months (2008)	Case study No outside support	N= 1; Stage IV PU	Demonstrate how the facility’s holistic approach, with PMDs in a major role, saves money and speeds healing	The patient had been cared for at another health care facility for 6 months with no improvement and poor quality of life At the rehab center, the wound was closed in 2.5 months with PMD, nutritional support, offloading, support surfaces, and socialization. Cost was 285,039 Swedish Krona versus 16,192 (5.7% of the cost of the failed treatment)

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Langemo DK, Black J[27]	National Pressure Ulcer Advisory Panel. Pressure ulcers in individuals receiving palliative care: a National Pressure Ulcer Advisory Panel white paper (2010)	Systematic review and advisory panel expert consensus No outside support	Systematic review/consensus	Review and summarize current scientific evidence for prevention and care of PUs in palliative care patients	PMDs are discussed independently from other dressing categories "PMDs are very absorptive, have a surfactant to help cleanse the wounds, and have been shown to decrease pain." Recommendations: Dressings "Consider use of a PMD for exudate control and cleansing (strength of evidence = B)" "Recommendation supported by direct scientific evidence from properly designed and implemented clinical series in humans providing statistical results that consistently support the recommendation"
Minniti CP, Eckman J, Sebastiani P, Steinberg MH, Ballas SK[28]	Leg ulcers in sickle cell disease (2010)	Review NIH grant funded	Review	Summarize the problem and recommended management of sickle cell leg ulcers	Under the management section, the only dressing mentioned is PMDs "The use of semipermeable PMD seems to promote healing in DFUs."
Edwards J, Mason S[29]	An evaluation of the use of PolyMem Silver in burn management (2010)	Facility evaluation (case series) No outside support	N= 8 patients with 10 burn wounds (50% full-thickness, 20% partial-thickness, 30% superficial)	Compare PMD outcomes to standard care	Persistent wound pain improved in all patients, low pain levels at dressing change, and low adherence to wound bed (completely atraumatic). Difficult to apply in some anatomical locations; however, high ease of application and conformability scores. Good wound exudate management. Acceptability to nurses: 100% would recommend, 80% had confidence in the dressing
Weissman O, Hundeshagen G, Harats M, et al[30]	Custom-fit PMD masks in the treatment of second degree facial burns (2013)	Cohort study with historical control No outside support	N= 16 patients with second-degree facial burns (8 prospective, 8 retrospective control)	Compare new treatment: PMD facial masks, with previous methods: topical antibiotic and steroid ointment	PMD group reepithelialized more quickly than control (6.5 days vs 8.5 days) PMD group had less wound site pain (average 2.6 vs 4.7), and 0 dressing change pain. Nurses attributed a less frequent need for dressing changes to the absorption of the PMDs and confirmed that no manual cleansing was needed at dressing changes with PMDs. PMDs save nurse time and dramatically decreased overall costs No areas of inflammation beyond actual area of burn (neurogenic inflammation) observed with PMDs

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Scott A[31]	PMDs for radiotherapy-induced skin damage (2014)	Facility evaluation (case series) Supported by dressing distributor	N= 20 patients with head or neck cancer who were undergoing radiation treatment with resultant radiotherapy-induced skin damage kept diaries for 4 weeks for qualitative analysis	Evaluate PMDs and compare to usual observations with standard treatment of topical aqueous cream with additional paraffin gauze when moist desquamation occurs	Documented reduction in: inflammation, pain medication, healing time, time of skin exposure during dressing changes due to no need for cleansing. Increase in comfort 13 patients developed radiation therapy oncology group (RTOG) 2; 5 developed RTOG 2.5; 2 developed RTOG 1 Reduction in skin reactions in first week of treatment, and 75% healed completely. 8 patients healed in 1 week, 5 healed in 2 weeks, 2 healed in week 3, 2 patients were improved but not healed at week 4. One patient withdrew at 2 days (could not tolerate anything on his neck), 2 others stopped using PMDs at week 3 Patients reported improved quality of life, increased sleep hours and independence Patients reported reduction in pain and increased comfort and cooling when using PMDs
Cahn A, Kleinman Y[32]	A novel approach to the treatment of diabetic foot abscesses - a case series (2014)	Case series No outside support	N= 6 patients with diabetic foot abscesses and osteomyelitis	Evaluate management of wounds with PMD silver rope and topical oxygen	All patients showed complete recovery in 2 to 9 months (average 5 months) and wounds have not recurred (average of 13.7 months follow-up)
Hegarty F, Wong M[33]	PMD for radiotherapy-induced skin reactions (2014)	Facility evaluation/case series Publication supported by dressing distributor (who is the manufacturer of one of the comparison products)	N= 23 patients who had undergone radiation treatment (colorectal, breast, gynecological, head, or neck) with resultant radiotherapy-induced skin damage	Compare PMDs with standard treatment of Aquaform hydrogel (Aspen Medical, UK), aqueous cream, N-A Ultra (Systagenix, UK), or no dressing at all	At baseline 48% (11) had RTOG 2, 48% (11) had RTOG 2.5, and 4% (1) had RTOG 3; for some areas (bowel, breast, gynecological), fixation of the dressing was challenging RTOG score improved by week 3; at week 4 only 7 patients remained in the evaluation PMDs associated with reduction in symptoms for dry and moist desquamation at week 3 By week 4, 2 more patients had healed, 1 patient developed skin infection and required antibiotics 12 patients (52%) recorded no pain at dressing changes at week 1; 2 recorded score of 7 Pain reduced from average 6.5 to 1.6 during evaluation. Pain increased in infected patient Diaries showed that PMDs led to pain reduction, cooling, and improvement in the skin Only 3 of 23 patients took morphine. Most took codeine, cocodamol, and paracetamol Dressing change pain was reduced and not related to the dressing

Table 1: Clinical evaluations and reviews of polymeric membrane dressings (PMDs)

Author(s)/reference	Title (year of publication)	Type of study/evaluation or publication type/support	Sample size/patient and wound description	Study/evaluation purpose	Key findings pertaining to PMDs
Davies SL, White RJ[34]	Defining a holistic pain-relieving approach to wound care via a drug free polymeric membrane dressing (2011)	Review Supported by manufacturer	Review	Review of the evidence supporting the claim that PMDs are drug-free pain-relieving dressings and effect on healing	PMDs reduce or prevent wound pain Nonadherent properties allow PMDs to be used for EB PMDs lead to faster healing times Patients report improved comfort levels Skin temperature is closer to normal with PMDs, indicating decreased inflammation Applying PMDs to injuries reduces spinal nerve-cell activation vs gauze or placebo foam Wounds do not routinely require cleansing when PMDs are used, which decreases pain PMDs reduce persistent (background) pain, apprehension, pain due to dressing adhesion, pain due to wound cleansing, all of which are additive and negatively impact healing
Benskin LL[35]	PolyMem Wic Silver Rope: A Multifunctional Dressing for Decreasing Pain, Swelling, and Inflammation (2012)	Review Supported by manufacturer	Review	Review of the evidence supporting the PMD silver rope wound filler	PMDs in general have a continuous wound cleansing system composed of a surfactant, glycerin, a super-absorbent, and a polyurethane substrate PMDs recruit nutrient-filled fluid into the body and absorb excess, balancing moisture PMDs are nonadherent and decrease persistent wound pain and inflammation Silver PMDs are antimicrobial without destructive silver toxicity Patients can manage tunneling wound dressing changes themselves with PMD rope Decreased pain and inflammation decreases ischemia and increases immune function and healing PMDs can be used safely in infected wounds and over tendon, vasculature, and bone Expect large quantities of pale yellow wound fluid the first week of PMD use

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Dabiri G, Damstetter E, Phillips T[36]	Choosing a Wound Dressing Based on Common Wound Characteristics (2016)	Review No outside support	Review of the literature	Critical review of the literature with recommendations of dressing types for various wound conditions	Choose wound dressings based upon fundamental wound characteristics PMDs are a recommended dressing type for superficial, deep, exudating, granulating, and eschar-covered wounds; they come in different thicknesses PMDs have been used in donor sites and abrasions without drying, are nonadherent, enhance autolytic debridement, continuously cleanse, and expedite healing PMDs keep wounds moist, and thicker versions are appropriate for heavily exudating wounds. Glycerol in PMDs prevents adherence and facilitates reepithelialization Silver PMDs decrease cytotoxicity "PMDs are revolutionizing the way dressings are made, as these dressings can be used on any type of wound."
Cutting KF, Vowden P, Wiegand C[38]	Wound inflammation and the role of a multifunctional PMD (2015)	Review Supported by the manufacturer	Review	Review of literature related to inflammation and wound healing with review of evidence supporting PMD's role	PMDs are effective in preventing the development of pain, bruising, swelling, and inflammation in the deep tissues beneath the skin, even when applied to intact skin Pain levels are significantly reduced with PMDs. PMDs have an analgesic effect PMDs lead to lower pain ratings and less postoperative swelling PMDs also cleanse wounds by loosening the bonds between slough/fibrotic tissue and healthy granulation tissue for effective autolytic debridement. This often excludes the need for wound cleansing at dressing changes, which has many benefits (listed) PMD moisturizer prevents the dressing from sticking, and draws fluid (including nutrition and growth factors) from deeper tissue to stimulate healing The superabsorbents draw wound fluid into the dressing and binds it in the dressing to balance moisture and prevent maceration. The membrane protects and controls moisture Inflammation is dysfunctional and results in delayed healing, pain, odor, and high levels of exudate production. PMDs address these factors and are highly suitable for a wide variety of wounds, reducing the risks of placing the wrong dressing on a wound PMDs reduce inflammation, swelling, pain, and create an optimal healing environment

Table 2. Posters presented at major conferences highlighting the use of polymeric membrane dressings (PMDs) by 144 independent authors (unsponsored work) (totals through December 31, 2015)

Wound type	# of posters	# of patients with PMDs
Arterial ulcers	6	35
Burn wounds	13	39
Diabetic foot ulcers	25	96
Donor sites (skin graft)	4	1203
Epidermolysis bullosa	10	46
Graft sites	7	11
Herpes zoster lesions	1	2
Mixed venous/arterial ulcers	4	8
Miscellaneous/other wounds	7	19
Pressure ulcers	41	388
Pyoderma gangrenosum	2	3
Radiation skin reactions	7	213
Skin tears	5	5
Surgical wounds:		
Sutured, stapled, or steri-stripped)	14	1233
Sinus surgery	2	246
Fasciotomy closure by secondary intention	2	16
Closed by secondary intention, other	5	35
Dehisced surgical	13	21
Plastic surgery, damaged into dermis, no incisions	2	40
Tracheostomy sites	2	163
Trauma	43	90
Tube sites (gastric)	1	10
Venous leg ulcers	25	66
TOTALS: 209 unique posters[a]		**3988 patients with PMDs**

[a]Note: when a poster discussed multiple wound types, data was divided to avoid duplication