Pressure ulcers: Prevention and management

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Learning objectives
After completing this learning activity, participants should be able to identify and the discuss the role of various pressure ulcer prevention strategies, including use of specialized support surfaces, repositioning, nutrition, dressings, topical agents; compare and contrast the different types of support surfaces; and recall the various aspects of pressure ulcer management and discuss the evidence for specific interventions in the realms of wound care fundamentals, nonsurgical therapy, and surgical therapy.

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Prevention has been a primary goal of pressure ulcer research. Despite such efforts, pressure ulcers remain common in hospitals and in the community. Moreover, pressure ulcers often become chronic wounds that are difficult to treat and that tend to recur after healing. Especially given these challenges, dermatologists should have the knowledge and skills to implement pressure ulcer prevention strategies and to effectively treat pressure ulcers in their patients. This continuing medical education article focuses on pressure ulcer prevention and management, with an emphasis on the evidence for commonly accepted practices. (J Am Acad Dermatol 2019;81:893-902.)

Key words: chronic wounds; debridement; dressings; management; nutrition; pressure injury; pressure sore; pressure ulcer; prevention; repositioning; support surface; surgery; therapy; treatment; wound care; wound healing; wounds.

Increased national attention has been given to pressure ulcers, yet they remain a significant source of morbidity and mortality and continue to pose a significant burden for patients and the health care system.[1] While pressure ulcers are often a consequence of other medical conditions or

Abbreviations used:

AP:	alternating pressure
CLP:	constant low-pressure
NPWT:	negative pressure wound therapy

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generally poor health, the vast majority of pressure ulcers are avoidable.[2] The prevention of pressure ulcers is therefore the goal, which is even more critical given the challenges and the high cost of treatment. Cornerstones of effective prevention strategies include the use of appropriate support surfaces, frequent repositioning, proper nutrition, and moisture management. The implementation of prevention strategies often necessitates higher upfront costs, yet evidence has shown this approach to be cost-reducing compared with standard care alternatives.[3-5] If an ulcer has already developed, appropriate wound care, nonoperative treatment, and surgical management as needed should be used in addition to all preventative care measures.

PREVENTION STRATEGIES

Repositioning

Key points

- **Pressure redistribution is the cornerstone of pressure ulcer prevention**
- **Frequent repositioning, low angle of bed incline, and optimal patient positioning can reduce the incidence of pressure ulcers**

Repositioning to avoid long periods of locally sustained pressure is as an essential element of pressure ulcer prevention. Expert opinion has traditionally advised repositioning every 2 hours, but recent guidelines from the National Pressure Ulcer Advisory Panel have omitted this recommendation because of a lack of evidence.[6] In a randomized study looking at repositioning every 2 hours versus 3 hours on a standard hospital mattress, a nonsignificant 7% decrease in pressure ulcer incidence was observed in the 2-hour repositioning group.[7] A post hoc analysis of these same data revealed that among stage 2 to 4 pressure ulcers, 14% in the 2-hour group versus 24% in the 3-hour group developed pressure ulcers.[8] When these same investigators compared 4-hour versus 6-hour repositioning on a viscoelastic foam mattress, a 14% decrease in pressure ulcer incidence was observed with more frequent repositioning.[7] In a large 2014 study that looked at the incidence of grade 2 or higher pressure ulcers in patients in the intensive care unit on mechanical ventilation using alternating pressure mattresses, 2-hour repositioning did not significantly decrease pressure ulcers compared with 4-hour repositioning.[9] Moreover, a recent cost-effectiveness analysis concluded that given the available clinical data, alternating 2- and 4-hour repositioning compared with continuous 4-hour repositioning may be marginally more effective clinically but is not an effective use of resources.[10]

Angle of incline and specific position are also relevant risk factors. The head of the bed should be kept at as low an angle of elevation as possible because shear and frictional forces increase with greater degree of incline. In addition, the 30° lateral tilt position, in which the patient is propped up laterally by pillows wedged under the buttocks and legs, has been proposed as advantageous to supine or 90° lateral positioning. The 30° tilt avoids direct support surface interface pressure with most bony prominences. A large randomized trial found that 30° lateral positioning plus 3-hour repositioning, compared with 90° lateral positioning plus 6-hour repositioning, significantly reduced pressure ulcer incidence by >70% after 28 days.[11]

Support surfaces

Key points

- **Specialized support surfaces, including mattresses and overlays, are designed to reduce pressure and minimize shear**
- **Constant low-pressure and alternating pressure supports reduce the incidence of pressure ulcers compared with standard mattresses**

In addition to reducing the duration of pressure via frequent repositioning, minimizing pressure magnitude is essential. A variety of support surfaces, including specialized beds, mattresses, mattress overlays, and cushions, are available that aim to reduce pressure and minimize shear. Moreover, these support surfaces may be classified as constant low-pressure (CLP) devices, which conform to body shape, or alternating pressure (AP) devices, which mechanically vary pressure.

CLP supports. Though high-quality trials are lacking, studies have generally shown that CLP devices are preferable to standard foam hospital mattresses.[12] High-specification foam,[13,14] bead-filled,[15] and water-filled[16] mattresses have all been found to decrease the incidence and severity of pressure ulcers in high-risk patients when compared with standard foam hospital mattresses. A recent meta-analysis of 5 trials comparing alternative foam mattresses with the hospital standard showed that the alternative foams were superior in reducing pressure ulcer incidence.[12] Notably, however, the "standard" mattresses in all these studies are typically poorly defined and variable by location and time. Among the various alternative foam mattresses, head-to-head comparisons have failed to show any significant differences.[12,14,17] High-specification foam mattresses with air overlays have not shown any benefit over the foam mattress alone.[12,18]

Likewise, the limited available data on head-to-head comparisons of other CLP support surfaces, including air mattresses, air and fluid overlays, and heel pressure relief devices, has not shown evidence favoring one material over any other.[19-24] There is some evidence that low-air-loss beds, which are air-filled mattresses that help control skin temperature and moisture via steady air flow over the skin, decrease the incidence of pressure ulcers compared with a standard hospital bed or static air overlay.[12,25] Medical sheepskins, first reported for pressure relief in the 1950s,[26] have shown evidence of benefit compared with standard care, significantly reducing pressure ulcer incidence in both hospitalized and patients who are in nursing homes.[27,28]

Wheelchair cushions, which are commonly recommended for and used by permanently immobile individuals, are available in many materials. While cushions have been shown to lower interface pressure,[29] studies of their efficacy in reducing pressure ulcer incidence are inconclusive and are limited by a lack of standardized comparisons.[30,31]

AP supports. AP mattresses and overlays contain numerous air-filled compartments that inflate and deflate in a coordinated fashion to continuously vary pressure across body sites. Studies of AP devices are few and heterogeneous, with most studies omitting details regarding air cell specifications and cycling times.[12] Limited evidence does suggest, however, that compared with a hospital's standard mattress, AP surfaces reduce the incidence of pressure ulcers.[16] Studies comparing different AP devices have not revealed any evidence of differences,[32-35] except for 1 study showing that a double-layer overlay may be more effective than single-layer devices.[36] A large randomized controlled trial comparing an AP mattress with an AP overlay found no difference in incidence of stage 2 or higher pressure ulcers.[35] The AP mattress, however, delayed mean time to ulceration by nearly 11 days and was found to have an 80% probability of reducing costs related to shorter hospital stays.[5]

CLP versus AP supports. Currently, there is insufficient evidence to say if or when AP versus CLP support surfaces are preferred. Studies that have attempted to shed light on this matter have generally shown no differences between groups, and a recent meta-analysis found no evidence to suggest otherwise.[12]

Nutrition

Key points

- **Nutritional deficiencies may promote skin breakdown**
- **Malnutrition is best diagnosed with tools that incorporate a patient history and physical examination**

Protein, calorie, vitamin, and mineral deficiencies are all logically implicated as elements contributing to skin breakdown. The importance of nutritional assessment to the prevention of pressure ulcers is apparent, as reflected by its inclusion in various society guidelines and risk factor assessment tools.[37] Many studies have found that malnutrition, weight loss, or eating problems are associated with pressure ulcer development.[38-41] Nonetheless, evidence from randomized controlled trials in support of specific interventions that prevent pressure ulcer development is currently lacking.[42]

Traditional markers of malnutrition, such as albumin and prealbumin, are negative acute-phase reactants that may go down in the setting of inflammation and that are also impacted by other factors, including liver function, kidney function, and hydration status.[43] The Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition no longer recommends the use of serum proteins for diagnosing malnutrition. Assessment methods that incorporate historical and physical examination elements, such as the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition guidelines or subjective global assessment, are now favored[43] (Table I).

Dressings

Key points

- **Prophylactic dressings can reduce the effects of friction and shear**
- **Dressings can also protect intact skin from maceration**

Dressings, including films, hydrocolloids, and foams, have been used prophylactically to prevent skin damage. These dressings may minimize the effects of friction or shear on at-risk body surfaces.[44] Nakagami et al[45] studied a modified hydrocolloid dressing for prevention of pressure ulcers over the trochanters. The dressing was randomized to either the right or left trochanter, with the opposite side receiving no dressing. While no pressure ulcers were reported over the 3-week study, "persistent erythema" was reduced from 29.7% (n = 11) on the control side to 5.5% (n = 2) on the dressing side. Another randomized study of 366 patients in an intensive care unit found that a soft silicone foam dressing applied over the sacrum lowered the incidence of pressure

Table I. Principal elements of nutritional assessment included in the American Society for Parenteral and Enteral Nutrition guidelines and subjective global assessment

History		Physical examination	
Nutrient intake*	Solids Liquids Supplements	Subcutaneous fat*	Under the eyes Between the fingers Chest, ribs, and iliac crest
Weight change*	Percent change in last 6 months Percent change in last 2 weeks	Muscle wasting*	Temples Clavicle Shoulder Scapula Quadriceps
Symptoms affecting oral intake	Dysphagia, nausea, or diarrhea	Edema/ascites*	Extent of lower extremity or sacral edema Ascites on examination or imaging
Functional* capacity	Ambulation Activities of daily living Grip strength		

*According to the American Society for Parenteral and Enteral Nutrition guidelines, deficiencies or positive findings in ≥2 of 6 of these categories are suggestive of malnutrition.

ulcers (0.7%) compared with the no-dressing control group (5.9%).[46] Likewise, Santamaria et al[47] found that soft silicone foam dressings reduced the incidence of sacral and heel pressure ulcers in 440 patients in an intensive care unit. The dressing intervention was ultimately cost-reducing compared with the control group, which had a higher incidence of pressure ulcers.[48] Dressings may also protect healthy skin from maceration related to incontinence, which can predispose the skin to superficial ulceration.[49]

Topical agents

Key point

- **Fatty acid creams may reduce the incidence of pressure ulcers**

Various creams, lotions, and ointments have been used as part of pressure ulcer prevention strategies, with the proposed mechanisms of action being a reduction in frictional forces and the promotion and maintenance of healthy skin.[50] Fatty acid creams have some limited evidence of efficacy, reducing pressure ulcer incidence in 2 randomized studies.[51,52] Other topicals containing various "active" ingredients, such as silicone, dimethyl sulfoxide, zinc, and others, have been tried[44] with little or even detrimental[53] effect.

MANAGEMENT

Key point

- **Principal elements of pressure ulcer prevention, including repositioning, the use of specialized support surfaces, and adequate nutrition, are also applicable to pressure ulcer management**

The management of pressure ulcers (Fig 1) consists of all the elements of pressure ulcer prevention, including the use of pressure-reducing support surfaces, repositioning, and adequate nutrition. Of note, however, no interventions in any of these categories have been demonstrated in high-quality studies to improve healing.[6,42,54,55] Additional treatment-specific interventions targeted at optimizing wound healing include off-loading, basic wound care fundamentals, and various other nonsurgical and surgical management options (Table II).

Pressure off-loading

Key point

- **Continuous off-loading of pressure from the site of ulceration is essential to healing**

Off-loading of pressure from the ulcer reverses the primary underlying etiology and is the most essential component of treatment. Pressure reduction is aided by the use of pressure-reducing support surfaces and frequent repositioning. Caution should be taken not only to relieve pressure from the site of ulceration but also to avoid causation of new pressure ulcers at other sites because of a singular focus on off-loading a particular site.

WOUND CARE FUNDAMENTALS

Cleansing and debridement

Key points

- **Saline or tap water are appropriate for wound cleansing**
- **Sharp debridement efficiently removes necrotic tissue and slough, reduces the bacterial burden, and helps eliminate phenotypically altered cells that impair healing**

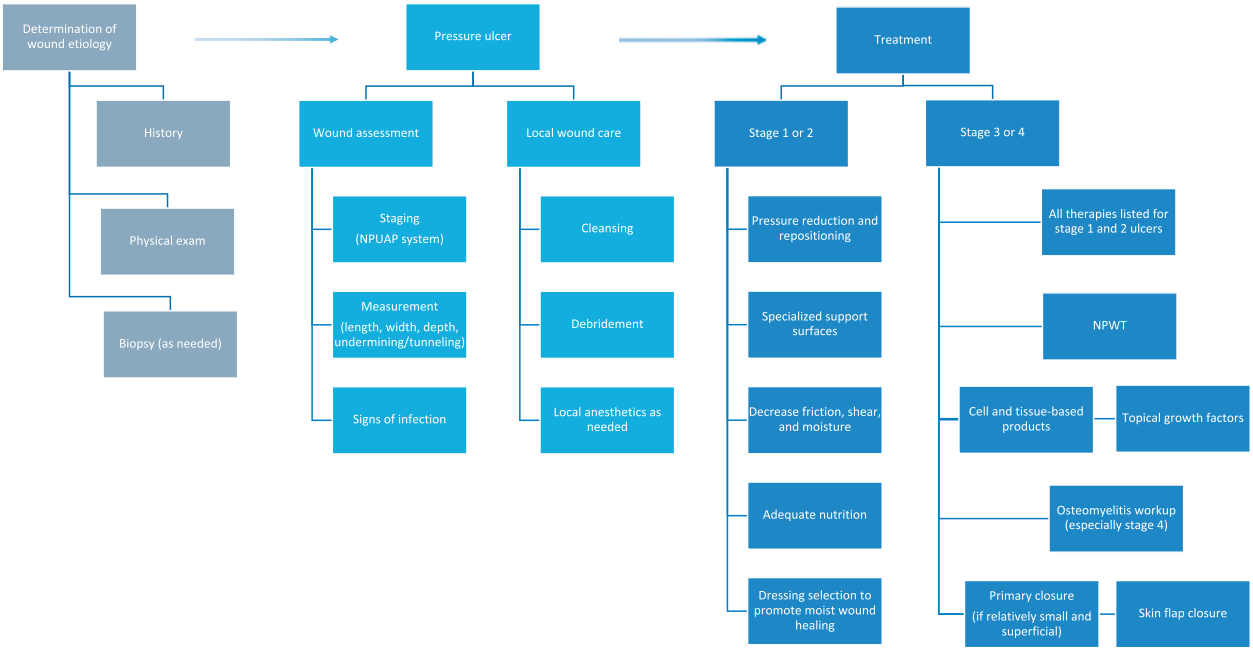

Fig 1. Flow chart for the management of pressure ulcers. NPUAP, National Pressure Ulcer Advisory Panel; NPWT, negative pressure wound therapy.

Cleansing wounds is generally thought to be an important element of wound care because it helps remove dead tissue, bacteria, and foreign bodies from the wound. No specific cleansing fluid or technique has proven best,[56] but saline or tap water are considered appropriate.[57] Wilcox et al[58] investigated the importance of debridement in wound healing and found that more frequent sharp debridement was associated with a faster time to complete wound healing in a sample of >300,000 wounds, 16.2% of which were pressure ulcers. Debridement removes necrotic tissue and slough, reduces bacterial burden and biofilm, and removes phenotypically altered fibroblasts and keratinocytes that are characteristic of nonhealing wounds.[59,60] In performing all these actions, debridement aims to convert a chronic wound environment to one more similar to the acute wound milieu, thus setting the wound on a healing trajectory.

Infection

Key points

- **Wound cultures are not indicated unless infection is suspected**
- **Stage 4 pressure ulcers are highly susceptible to osteomyelitis**

Signs of infection, such as increased pain, warmth, erythema, drainage, or systemic symptoms, should be regularly assessed. Cytotoxic agents like hydrogen peroxide and povidone-iodine should be avoided. Wounds with a heavy bioburden may benefit from cadexomer iodine, a slow-release paste, that is the only topical antibiotic with evidence for improving time to complete healing in chronic wounds.[61] When infection is suspected, oral antibiotics should be initiated and later refined as necessary based on culture results or the lack of a clinical response.[62] Routine wound culture should not be performed in cases where infection is not suspected. Deep wounds and those with exposed bone are susceptible to osteomyelitis, which is best detected on magnetic resonance imaging or bone biopsy[63] and that necessitates intravenous antibiotic therapy.

Dressing selection

Key points

- **Dressings that promote a moist wound healing environment should be selected**
- **Antibacterial dressings containing silver or honey lack evidence for long-term use**

Dressings should be selected that promulgate a moist wound healing environment, with the goal of finding a balance between exudate absorption and moisture retention[64] (Table III). Excess fluid over the wound may lead to maceration, irritation, and the breakdown of surrounding healthy skin. Antibacterial dressings containing silver or medical honey are often used for bioburden control but lack evidence for long-term use.[61] Recent systematic reviews have found no evidence for any particular

Table II. Treatment of pressure ulcers

Treatment	Level of evidence*	Reference(s)
Cellular and tissue-based products	III	Brem et al,[76] Beers et al,[77] Johnson et al,[78] and Levy et al[79]
Debridement (sharp)	III	Wilcox et al[58]
Dressing selection for moist wound healing environment	IB	Westby et al[66]
Negative pressure wound therapy	IB	Gupta and Ichioka,[72] Mouës et al,[74] and Dwivedi et al[75]
Nutritional supplementation (if evidence of malnutrition)	IV	Langer and Fink[42] and Gould et al[57]
Platelet-derived growth factor	III	Harrison-Balestra et al[67]
Platelet-rich plasma	III	Scevola et al[68]
Repositioning	IV	Moore and Cowman[55]
Specialized support surfaces	IB	McInnes et al[54]
Surgical management		
Primary surgical closure	IV	
Skin flap	III	Thiessen et al[86] and Kuo et al[89]
Wound cleansers	IB	Moore and Cowman[56]

*Level IA evidence includes evidence from metaanalysis of randomized controlled trials; level IB evidence includes evidence from ≥1 randomized controlled trial; level IIA evidence includes evidence from ≥1 controlled study without randomization; level IIB evidence includes evidence from ≥1 other type of experimental study; level III evidence includes evidence from nonexperimental descriptive studies, such as comparative studies, correlation studies, and case-control studies; and level IV evidence includes evidence from expert committee reports or opinions or clinical experience of respected authorities.

dressing type associated with more rapid healing,[65,66] which highlights the importance of tailoring dressing choice to the individual wound at a given point in time.

NONSURGICAL THERAPIES

Topical agents

Key point

- **Topicals agents that contain growth factors may be considered for pressure ulcers that do not respond to other treatments**

Topical agents have the theoretical advantage of improving the healing of pressure ulcers that do not respond to initial conservative care while potentially mitigating the need for surgical repair. Platelet-derived growth factor has been approved by the US Food and Drug Administration for the treatment of diabetic foot ulcers and has been reported to be effective and well-tolerated in the management of pressure ulcers.[67] Other experimental topical agents include platelet-rich plasma,[68,69] activated donor macrophages,[70] and phenytoin,[71] but the evidence for and availability of these treatments is limited. The Wound Healing Society recommends the consideration of topical growth factors, such as platelet-derived growth factor or platelet-rich plasma, for pressure ulcers that fail to respond to other treatments.[57]

Negative pressure wound therapy

Key points

- **Negative pressure wound therapy may accelerate healing time in stage 3 or 4 pressure ulcers**
- **Negative pressure wound therapy can help optimize the wound bed before surgical closure**

Negative pressure wound therapy (NPWT) may be advantageous for stage 3 or 4 pressure ulcers. NPWT has several potential benefits, including improved exudate management, increased wound perfusion, stimulation of granulation tissue formation, and reduced bacterial load.[72,73] NPWT can help optimize the wound bed for surgical closure or stimulate healing in stalled wounds that are not amenable to surgery. While high-quality data from large prospective trials are lacking, small randomized controlled trials and retrospective analyses have found significant reductions in wound size with the use of NPWT compared with standard of care dressings.[57,72,74,75]

Cellular and tissue-based products

Key point

- **A variety of cellular and acellular matrices have been reported to improve healing of pressure ulcers, but evidence from clinical trials is lacking**

Table III. Dressing categories and their advantages or disadvantages

Dressing	Use	Advantages	Disadvantages
Hydrogel	Dry wounds with or without eschar	Promotes autolytic debridement; adds moisture to a dry wound bed	Can cause maceration of surrounding healthy skin
Film	Minimally exudative wounds	Transparency allows wound to be seen	Does not absorb or allow drainage of fluid; adhesive coating may disturb reepithelialization upon removal
Hydrocolloid	Mildly exudative wounds	Gelling property when exposed to exudate promotes moist wound healing; waterproof and can stay in place for days	Minimally absorptive; can cause maceration under the dressing
Foam	Moderately exudative wounds	Absorbent and moisture retentive; available with adhesive borders; can use as a secondary dressing for highly exudative wounds	Can dry out wound bed if low exudate volume
Alginates and hydrofiber	Highly exudative wounds	Very absorbent	May dry out and adhere to wound bed, causing pain and trauma upon removal

Cellular and tissue-based products are cellular and acellular matrices that are used to treat chronic wounds. Evidence for the use of these products specifically for pressure ulcers is limited, but successful healing of stage 3 and 4 pressure ulcers has been reported with a human bilayered skin substitute,[76] acellular porcine-derived small intestinal submucosa,[77] and placental membrane products,[78] among others.

Of note, pressure ulcers often result in deep, undermined, or tunneling wounds that are not suitable for the application of cellular and tissue-based products, which are typically produced as flat sheets. A flowable acellular matrix comprised of micronized human cadaveric dermis (Cymetra; LifeCell Corp, Branchburg, NJ) is available that easily passes through an 18-gauge needle and can be injected onto the wound.[79] The flowable dermal matrix fills sinus tracts and crevices and provides a collagen scaffold that supports fibroblast migration and dermal regeneration. This matrix has been reported to support the healing of chronic wounds, including both deep and tunneling pressure ulcers.[79,80]

Hyperbaric oxygen

Key point

- **No evidence exists for the use of hyperbaric oxygen in the treatment of pressure ulcers**

Though hyperbaric oxygen may improve the healing of certain wounds, such as diabetic foot ulcers with osteomyelitis, no benefits of hyperbaric oxygen have been shown for pressure ulcers.[57]

SURGICAL MANAGEMENT

Key point

- **Skin flaps with or without muscle transfer are the principal surgical method of wound closure for pressure ulcers**

Several surgical techniques have been used to close pressure ulcers, though data from randomized trials are lacking.[81] The primary closure of relatively small nonhealing stage 2 or 3 pressure ulcers may be attempted when immediate closure is desired. While this relatively simple procedure can be performed in the clinic setting, wound dehiscence is a common complication.

For more extensive stage 3 or 4 pressure ulcers, surgical management with a skin flap is indicated when wounds show little chance of healing with more conservative management. Intraoperative bone biopsy specimens should be obtained for culture and sensitivity when osteomyelitis is suspected.[82] The removal of underlying bony prominences is recommended to help relieve pressure points.[57,83] Lower local recurrence rates with ostectomy were suggested by 1 small study.[84] Care must be taken, however, not to remove bone in excess, because doing so may expose critical deep structures or produce new unnatural weight-bearing skin surfaces.[57]

Skin grafts are generally not used for pressure ulcers because they do not typically provide enough strength or bulk to cover the wound.[85] A variety of skin flap techniques have been successfully used for pressure ulcer closure.[85] Though muscle has been presumed to be a critical element of successful skin flaps for pressure ulcers, evidence now suggests that

muscle transfer is not necessary.[86] In retrospective analyses, there do not appear to be any significant differences between musculocutaneous, fasciocutaneous, and perforator-based flaps with respect to postoperative complications or recurrence rates.[86-89] Therefore, patient and wound characteristics should be the most important factors in determining the choice of flap technique.[90]

In conclusion, pressure ulcers continue to be a significant burden for patients and society, with the need ongoing for more effective prevention and treatment strategies. High-quality studies comparing many of the available interventions are still needed. Regardless of the specific intervention, however, pressure ulcers undoubtedly require a multifaceted approach that optimizes pressure relief, nutrition status, and proper wound care, as well as nonsurgical and surgical treatments as needed.

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