Pressure Ulcer Healing Literature Review

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NUTRITION

Ascorbic acid

ter Riet G, Kessels AG, Knipschild PG. Randomized clinical trial of ascorbic acid in the treatment of pressure ulcers. Journal of Clinical Epidemiology 1995 Dec;48(12):1453-60.
Setting: 10 long-term care centers; 1 hospital
Sample: 88 residents
Design: Randomized controlled trial
Results and conclusions: No significant difference in healing time between the intervention and control groups. No significant difference in pressure ulcer healing time between the intervention group who received 500 mg ascorbic acid and the control group who received 10 mg ascorbic acid.

Caloric intake

Bergstorm N, Braden BJ. Nutritional status during the development and resolution of pressure sores. Key aspects of recovery: improving nutrition, rest, and mobility. New York: Springer Publishing; 1990. p. 183-7.
Setting: Nursing home
Sample: 200 residents
Design: Prospective cohort study
Results and conclusions: Those without pressure ulcers and those with pressure ulcers that healed had a significantly higher caloric intake than those with pressure ulcers that did not heal ($p<0.001$). Subjects with pressure ulcers that did not heal had lower intake of zinc than the other two groups. Monitoring nutritional status and ensuring adequate nutrition intake may help prevent pressure ulcers and heal pressure ulcers faster.

Collagen protein hydrolysate supplement

Lee SK, Posthauer ME, Dorner B, et al. Pressure ulcer healing with a concentrated, fortified, collagen protein hydrolysate supplement: a randomized controlled trial. Advanced Skin and Wound Care 2006 Mar;19(2):92-6.
Setting: Long- term care facilities
Sample: 89 patients
Design: Randomized controlled trial
Results and conclusions: Patients with standard care plus the supplement had significantly better Pressure Ulcer Scale for Healing (PUSH) tool scores compared with control ($p<0.05$). By week 8, Pressure Ulcer Scale for Healing (PUSH) tool scores showed approximately twice the rate of pressure ulcer healing in the treatment group compared with the control group. A concentrated, fortified, collagen protein hydrolysate supplement may be of benefit to long-term-care residents who have pressure ulcers.

Dietary protein-61g protein/L

Breslow RA, Hallfrisch J, Guy DG, et al. The importance of dietary protein in healing pressure ulcers. Journal of the American Geriatric Association 1993 Apr;41(4):357-62.
Setting: Long-term care facility

Sample: 28 residents
Design: Nonrandomized clinical trial
Results and conclusions: Patients who received supplements with 24% protein had a greater reduction in pressure ulcer area than patients who received supplements with 14% protein. Decrease in pressure ulcer area was significantly correlated with dietary protein intake per kg body weight ($p<0.01$) and caloric intake per kg body weight ($p<0.03$). High protein intake correlates with improved wound healing.

Good nutritional status at baseline

Van Rijswijk L, Polansky M. Predictors of time to healing deep pressure ulcers. Ostomy Wound Management 1994 Oct;40(8):40-2, 44, 46-8 passim.
Setting, sample, and design not available
Results and conclusions: Healing time was significantly reduced in patients with good nutritional status ($p<0.001$). After 2 weeks of treatment, ulcers in patients who were 60 to 70 years old, who had good nutritional status at baseline, and whose ulcers reduced at least 39 percent in size after 2 weeks were found to heal more rapidly.

Nutrient supplements-FORTA supplement

Welch PK, Dowson M, Endres JM. The effect of nutrient supplements on high-risk long-term care residents receiving pureed diets. Journal of Nutrition and the Elderly 1991;10(3):49-62.
Setting: Nursing home
Sample: 15 residents
Design: Nonrandomized prospective clinical trial
Results and conclusions: Decubitus status was monitored and 7 of the 10 residents who had some form of decubiti demonstrated signs of complete or partial healing. No mention of p value. Indirectly demonstrates efficacy of nutrient supplements in the few pressure ulcer patients included to promote increase in albumin and healing of pressure ulcers.

SURFACES

Air-fluidized beds

Allman RM, Walker JM, Hart MK, et al. Air-fluidized beds or conventional therapy for pressure sores: a randomized trial. Annals of Internal Medicine 1987 Nov;107(5):641-8.
Setting: Acute care setting
Sample: 65 patients
Design: Randomized controlled trial
Results and conclusions: Significant median decrease in pressure ulcer surface area for patients with air-fluidized beds compared with control ($p=0.01$). Air-fluidized beds are associated with pressure ulcer healing.

Bennett RG, Bellantoni MF, Ouslander JG. Air-fluidized bed treatment of nursing home patients with pressure sores. Journal of the American Geriatrics Society 1989 Mar;37(3):235-42.
Setting: Nursing home facility
Sample: 95 residents
Design: Retrospective chart review
Results and conclusions: Only 14% of pressure ulcers healed completely and 44% of pressure ulcers had a reduction of $\geq$50% in surface area. No control group was used in the study. These results indicate that although air-fluidized beds can be used to treat pressure sores successfully, no simple criteria exist to predict which patients will benefit from this treatment.

Munro BH, Brown L, Heitman BB. Pressure ulcers: one bed or another? Geriatric Nursing 1989 Jul-Aug;10(4):190-2.
Setting: VA medical center
Sample: 40 patients
Design: Randomized controlled trial
Results and conclusions: The mean size of pressure ulcers in the test group shrunk significantly over time ($p<0.05$) while ulcers in the control group expanded over time. Mean size of pressure ulcers in patients with air-fluidized mattresses decreased while mean size of control patients' ulcers increased over time.

Air-fluidized support surfaces

Ochs F, Horn S, Smout R. Comparison of air-fluidized therapy with other support surfaces used to treat pressure ulcers in nursing home residents. Ostomy Wound Management 2005 Feb;51(2):38-68.
Setting: Long-term care facilities and a specialized pressure ulcer care center
Sample: 664 residents
Design: Retrospective observational study
Results and conclusions: Significant differences were found in pressure ulcer healing rates for residents with air-fluidized support surfaces compared with residents on other surfaces ($p<0.007$). Patients with pressure ulcers on air-fluidized surfaces had statistically significant faster healing rates (particularly for stage III and stage IV ulcers) compared with patients on low air-loss and replacement mattresses.

Air suspension bed

Day A, Leonard F. Seeking quality care for patients with pressure ulcers. Decubitus 1993 Jan;6(1):32-43.
Setting: Acute teaching hospital
Sample: 83 patients
Design: Randomized controlled trial
Results and conclusions: No significant difference in surface area of pressure ulcers in the different treatment groups. Change in surface area of pressure ulcers: No significant difference when all stages of ulcers were analyzed together. Stage III and IV ulcers had greater decrease in area with the air suspension bed.

Alternating pressure overlays

Nixon J, Cranny G, Iglesias C, et al. Randomized controlled trial of alternating pressure mattresses compared with alternating pressure overlays for the prevention of pressure ulcers: PRESSURE (Pressure Relieving Support Surfaces) trial. British Medical Journal doi:10.1136/bmj.38849.478299.7C (published June 1, 2006).
Setting: 11 hospitals
Sample: 113 patients
Design: Randomized controlled trial
Results and conclusions: No significant differences in pressure ulcer healing time or wound grade between the groups of patients on mattresses and overlays. Thirty-four percent of patients had pressure ulcers that healed in the overlay group compared with 35% of patients in the mattress group. No difference was found in healing properties of alternating pressure overlays compared with alternating pressure mattresses.

Foam mattress

Warner DJ. A clinical comparison of two pressure-reducing surfaces in the management of pressure ulcers. Decubitus 1992 May;5(3):52-5, 58-60, 62-4.

Setting: Medical-surgical, critical care, and skilled nursing units
Sample: 20 patients
Design: Nonrandomized clinical trial
Results and conclusions: No significant differences in clinical outcomes for the two groups.

Generic total contact seat

Rosenthal MJ, Felton RM, Nastasi AE, et al. Healing of advanced pressure ulcers by a generic total contact seat: two randomized comparisons with low-air-loss bed treatments. Archives of Physical Medicine and Rehabilitation 2003 Dec;84(12):1733-42.
Setting: Long-term care facilities
Sample: 207 residents
Design: Randomized controlled trial
Results and conclusions: At 4 weeks, pressure ulcer status score was lowest for the generic total contact seat ($p<0.0001$), compared with low-air-loss beds and upgraded bed overlays. Faster healing and better function indicate that treatment using the generic total contact seat is superior to low-air-loss bed therapy, which is standard care for advanced pressure ulcers.

Low-air-loss bed

Ferrell BA, Osterweil D, Christenson P. A randomized trial of low-air-loss beds for treatment of pressure ulcers. Journal of the American Medical Association 1993 Jan 27;269(4):494-7.
Setting: Teaching nursing homes
Sample: 84 residents
Design: Prospective, randomized, controlled trial
Results and conclusions: Statistically significant improvement (threefold) in median rate of healing for low-air-loss beds compared with foam mattresses (9.0 vs. 2.5 mm^2/d; $p=0.0002$). Pressure ulcer healing for residents on low-air-loss beds was significantly better compared with foam mattresses.

Pegasus airwave system

St. Claire M. Survey of the uses of the Pegasus airwave system in the United Kingdom. Journal of Tissue Viability 1992;2(1):9-16.
Setting: Hospices and hospitals
Sample: 428 patients
Design: Cross-sectional survey
Results and conclusions: Significantly increased signs of healing in patients using Pegasus airwave system (PAWS) for >5 days ($p<0.0001$). Signs of healing were seen more frequently in patients using PAWS >5 days.

DEBRIDEMENT

Amorphous hydrogel

Bale S, Banks V, Haglestein S, et al. A comparison of two amorphous hydrogels in the debridement of pressure sores. Journal of Wound Care 1998 Feb;7(2):65-8.
Setting: Not available
Sample: 50 patients
Design: Randomized controlled, assessor-blind clinical trial
Results and conclusions: There were no statistically significant differences in comfort, wound odor, surrounding skin condition, or time to debridement between the two groups.

Thomas DR, Goode PS, LaMaster K, et al. Acemannan hydrogel dressing versus saline dressing for pressure ulcers: a randomized controlled trial. Advanced Wound Care 1998 Oct;11(6):273-6.
Setting: Skilled nursing facilities and home health care agencies
Sample: 30 patients
Design: Randomized controlled trial
Results and conclusions: No significant difference was observed in complete healing between the treatment (amorphous hydrogel group) and the control groups (moist saline gauze dressing) (odds ratio 0.93, 95% confidence interval 0.16, 5.2). This study indicates that the acemannan hydrogel dressing is as effective as, but not superior to, a moist saline gauze wound dressing for the management of pressure ulcers.

Collagenase

Boxer AM, Gottesman N, Bernstein H, et al. Debridement of dermal ulcers and decubiti with collagenase. Geriatrics 1969 Jul;24(7):75-86.
Setting: Community hospital inpatient and outpatient settings
Sample: 47 patients, 50 ulcers
Design: Blinded, randomized controlled trial
Results and conclusions: Collagenase with neomycin versus without neomycin was not significantly different, but collegenase was significantly more effective than the control treatment ($p<0.01$). In 50 closely followed ulcers, mean time to complete debridement was 10.5 days. Collegenase was more effective than control treatment ($p<0.01$).

Rao DB, Sane PG, Georgiev EL. Collagenase in the treatment of dermal and decubitus ulcers. Journal of the American Geriatrics Society 1975 Jan;23(1):22-30.
Setting: Chronic care hospital
Sample: 21 patients
Design: Randomized trial
Results and conclusions: Reduction in pressure ulcer healing, odor, and inflammation from start to finish was significant at ($p<0.05$). Treatment with collagenase significantly reduced necrotic tissue ($p<0.01$) and increased granulation tissue ($p<0.05$). Treatment with collagenase significantly improved outcomes.

Debrisan

Shand JE, McClemont E. Recent advances in the treatment of pressure sores. Paraplegia 1979 Nov;17(4):400-8.
Setting: Hospital
Sample: 32 pressure ulcers
Design: Randomized controlled trial
Results and conclusions: Less time to debridement in Debrisan-treated ulcers than other ulcers.

Fibrinolysin/deoxyribonuclease

Pullen R, Popp R, Volkers P, et al. Prospective randomized double-blind study of the wound-debriding effects of collagenase and fibrinolysin/deoxyribonuclease in pressure ulcers. Age and Ageing 2002 Mar;31(2):126-30.
Setting: 17 hospitals
Sample: 135 patients
Design: Prospective randomized double-blind trial

Results and conclusions: No significant difference between outcomes in patients who received collagenase compared with those who received fibrinolysin (p=0.115). There was no evidence of a difference between collagenase and fibrinolysin/deoxyribonuclease in the debridement of pressure ulcers.

Hydrogel only

Martin SJ, Corrado OJ, Kay EA. Enzymatic debridement for necrotic wounds. Journal of Wound Care 1996 Jul;5(7):310-1.
Setting: Not available
Sample: 17 subjects
Design: Randomized, double-blind, controlled trial
Results and conclusions: Fewer days were needed for healing in the hydrogel-only group compared with enzyme/hydrogel group; however, results were not statistically significant. Both treatments led to eschar removal and differences in pressure ulcer healing were not statistically significant.

Maggot therapy

Sherman RA. Maggot versus conservative debridement therapy for the treatment of pressure ulcers. Wound Repair and Regeneration 2002 Jul-Aug;10(4):208-14.
Setting: Hospital
Sample: 103 patients
Design: Prospective, comparative study
Results and conclusions: In 3 weeks, maggot-treated wounds contained significantly less (one-third) necrotic tissue (p=0.05) and twice the granulation tissue (p<0.001) compared with control wounds. Maggot therapy was more effective and efficient in debriding chronic pressure ulcers than the conventional treatments prescribed. Patients readily accepted maggot therapy, and adverse events were uncommon.

Steenvoorde P, Jacobi CE, Oskam J. Maggot debridement therapy: free-range or contained? An in-vivo study. Advanced Skin and Wound Care 2005 Oct;18(8):430-5.
Setting: Hospital surgical ward inpatients and outpatients
Sample: 64 patients
Design: Nonrandomized clinical trial
Results and conclusions: Significantly better outcomes with the free-range versus the contained technique (p=0.028). This clinical in vivo study supports in vitro studies that showed containment of maggots were found to reduce the effectiveness of maggot debridement therapy.

Nonwoven sponges

Mulder GD. Evaluation of three nonwoven sponges in the debridement of chronic wounds. Ostomy Wound Management 1995 Apr;41(3):62-4, 66-7.
Setting: Not available
Sample: 15 patients
Design: Nonrandomized evaluation
Results and conclusions: The 8 x 8 mesh product more effectively debrided the wounds than the nonwoven sponges with the smaller apertures. The study results suggest that open mesh 100 percent cotton nonwoven sponges are effective in debriding nonviable tissue with minimal damage. The 8x8 mesh product is significantly more effective than other nonwoven sponges.

Water jet

Granick MS, Posnett J, Jacoby M, et al. Efficacy and cost-effectiveness of a high-powered parallel water jet for wound debridement. Wound Repair and Regeneration 2006 Jul-Aug;14(4): 394-7.
Setting: University hospital
Sample: 62 patients
Design: Randomized controlled trial
Results and conclusions: The intervention group who underwent water jet debridement had significantly fewer procedures ($p<0.002$) than the control group who received surgical debridement. The water jet group had significantly fewer procedures than the conventional group. Based on these results, the use of the new device in appropriate patients is expected to lead to cost savings of approximately $1,900 per patient.

Zinc oxide

Agren MS, Stromberg HE. Topical treatment of pressure ulcers: a randomized comparative trial of Varidase and zinc oxide Scandinavian Journal of Plastic and Reconstructive Surgery 1985;19(1):97-100.
Setting: Hospital inpatient and outpatient settings
Sample: 28 patients
Design: Randomized comparative trial
Results and conclusions: No significant differences in disappearance of necrotic tissues were found between treatments. The data suggest that zinc oxide and Varidase regimens are about equally effective in the treatment of necrotic tissue.

CLEANSERS

Body wash and a skin protectant

Thompson P, Langemo D, Anderson J, et al. Skin care protocols for pressure ulcers and incontinence in long-term care: a quasi-experimental study. Advanced Skin and Wound Care 2005 Oct;18(8):422-9.
Setting: Long- term care facilities
Sample: 136 residents
Design: Not available
Results and conclusions: Significant decrease in the prevalence of stage I and II pressure ulcers ($p=0.05$), the incidence of pressure ulcers ($p=0.01$), and healing time ($p=0.001$). Implementation of skin care protocols that included use of a body wash and a skin protectorant reduced the incidence of stage I and stage II pressure ulcers and decreased healing time.

Dental irrigating device

Diekmann JM. Use of a dental irrigating device in the treatment of decubitus ulcers. Nursing Research 1984 Sep-Oct;33(5):303-5.
Setting: Long-term care facilities
Sample: 16 residents
Design: Randomized trial
Results and conclusions: Experimental wounds decreased in size by 51% compared with 13% of control wounds. Due to small sample size and large standard deviation, this change was not statistically significant. Dental irrigation devices were not significantly more effective than conventional cleansing methods.

Dey-Wash

Weller K. In search of efficacy and efficiency: an alternative to conventional wound cleansing modalities. Ostomy Wound Management 1991 Nov- Dec;37:23-8.
Setting: Not available
Sample: 30 patients
Design: Randomized trial
Results and conclusions: In more than 80% of the patients, Dey-Wash cleansed the wound of exudates and debris in less than half the time of the control group receiving treatment with the bulb syringe method. Use of Dey-Wash cleanser is both efficient and effective.

HYDROCOLLOIDS

BioFilm hydrogel

Darkovich SL, Brown-Etris M, Spencer M. BioFilm hydrogel dressing: a clinical evaluation in the treatment of pressure sores. Ostomy Wound Management 1990 Jul-Aug;29:47-60.
Setting: Acute care facilities and nursing homes
Sample: 90 residents
Design: Randomized controlled trial
Results and conclusions: BioFilm dressings demonstrated a healing advantage over hydrocolloid dressings. Study needs to be repeated due to t-test assumption violations. The majority of pressure ulcers treated with either dressing healed; however, the study needs to be repeated due to t-test assumption violations.

Calcium alginate and hydrocolloid dressing

Belmin J, Meaume S, Rabus MT, et al. Sequential treatment with calcium alginate dressings and hydrocolloid dressings accelerates pressure ulcer healing in older subjects: a multicenter randomized trial of sequential versus nonsequential treatment with hydrocolloid dressings alone. Journal of the American Geriatrics Society 2002 Feb; 50(2):269-74.
Setting: 20 geriatric hospital wards
Sample: 110 older patients with stage III or IV pressure ulcers
Design: Open, randomized, multicenter, parallel-group trial
Results and conclusions: Mean surface area reduction was significantly greater in experiment group vs. control group ($p<0.0001$). Treatment using first calcium alginate and then hydrocolloid dressing promotes faster healing than treatment with hydrocolloid dressings alone.

Collagen and collegenase

Graumlich JF, Blough LS, McLaughlin RG, et al. Healing pressure ulcers with collagen or hydrocolloid: a randomized controlled trial. Journal of the American Geriatrics Society 2003 Feb;51(2):147-54.
Setting: 11 nursing homes
Sample: 65 residents
Design: Randomized controlled trial
Results and conclusions: There were no significant differences in healing outcome between collagen and hydrocolloid. Collagen was more expensive and offered no major benefits to patients otherwise eligible for hydrocolloid treatment.

Muller E, van Leen MW, Bergemann R. Economic evaluation of collagenase-containing ointment and hydrocolloid dressing in the treatment of pressure ulcers. Pharmacoeconomics 2001;19(12):1209-16.

Setting: Hospital Inpatients
Sample: 24 patients
Design: Randomized clinical trial
Results and conclusions: Collagenase treatment is more cost effective and requires significantly less time to heal than hydrocolloid dressing treatment in treating stage IV pressure ulcers. The study showed collagenase treatment to be more cost effective than the hydrocolloid treatment in patients with stage IV pressure sores on the heel and the amount of time needed for wound healing was shorter.

Gelatin sponge (gelfoam), gelatin powder (gelfoam powder), enzyme ointment (elase)

Young CG, Oden PW. Treatment of decubitus ulcers in paraplegic patients: a comparison of three topical agents—gelatin sponge (gelfoam), gelatin powder(gelfoam powder), enzyme ointment (elase). Southern Medical Journal 1973 Dec;66(12):1375-8.
Setting: VA hospital
Sample: 150 ulcers in 82 patients
Design: Nonrandomized uncontrolled trial
Results and conclusions: Pressure ulcers were divided into three groups of 50, debrided, and treated daily with gelatin sponge, gelatin powder, or enzyme ointment, followed by dry gauze. Wounds in all three groups healed at about the same rate.

Hydragan

Saydak SJ. A pilot test of two methods for the treatment of pressure ulcers. Journal of Enterostomal Therapy 1990 May-Jun;17(3):139-42.
Setting: Long-term care ward at VA medical center
Sample: 11 residents
Design: Controlled trial (each patient had two ulcers; one ulcer received absorptive dressing and one received dry gauze).
Result sand conclusions: The ulcers treated with the absorptive dressings showed improvement over those treated with dry gauze as measured by ulcer length and depth.

Hydrocellular foam dressing

Viamontes L, Temple D, Wytall D, et al. An evaluation of an adhesive hydrocellular foam dressing and a self-adherent soft silicone foam dressing in a nursing home setting. Ostomy Wound Management 2003 Aug;49(8):48-52, 54-6, 58.
Setting: Nursing homes
Sample: 1,891 residents
Design: 5-year retrospective descriptive study
Results and conclusions: Wounds in the hydrocellular group were larger (mean area 7.53 cm^2) and took longer to heal (mean 70.1 days) than those in the silicone dressing group (mean area 5.5 cm^2, 39.2 days) but the proportion of ulcers healed was the same (63%) in both groups. Most chronic wounds managed with either dressing will heal after an average of 70 days. The differences between the two dressings are minimal and periwound skin stripping is uncommon.

Hydrocolloid dressing

Alm A, Hornmark AM, Fall PA, et al. Care of pressure sores: a controlled study of the use of a hydrocolloid dressing compared with wet saline gauze compresses. Academy of Dermatology and Venereology Supplement (Stockh) 1989;149:1-10.
Setting: Long-term care ward
Sample: 50 residents

Design: Randomized, controlled, single-blind trial
Results and conclusions: Significant decrease in the area of hydrocolloid-treated ulcers at week 6 ($p=0.016$) compared with ulcers treated with wet saline gauze compresses. Hydrocolloid dressing saves nursing time and significantly improves wound healing on a number of intermediate parameters (wound surface area changes), but healing did not reach statistically significant differences using survival analysis.

Bouza C, Saz Z, Munoz A, et al. Efficacy of advanced dressings in the treatment of pressure ulcers: a systematic review. Journal of Wound Care 2005 May;14(5):193-9.
Setting: Various
Sample: Various
Design: Meta-analysis of randomized, quasi-randomized, and controlled clinical trials
Results and conclusions: A few studies reported significant benefits for hydrocolloids. No significant differences were observed in healing rates in studies comparing dextranomer, polyurethane, or hydrogel against conventional dressings. Analyses of studies comparing hydrocolloids with polyurethane dressings failed to show significant differences. Other advanced dressings were compared inconsistently. Comparisons showed greater efficacy of hydrocolloid dressings but failed to confirm advantages of other advanced dressings compared with conventional ones.

Gorse GJ, Messner RL. Improved pressure sore healing with hydrocolloid dressings. Archives of Dermatology 1987 Jun;123(6):766-71.
Setting: VA center
Sample: 52 patients
Design: Randomized controlled trial
Results and conclusions: In the hydrocolloid dressing group, 66 (86.8%) pressure ulcers improved compared with 36 (69.2%) pressure ulcers in the wet-to-dry dressings group. In the hydrocolloid dressing group, pressure ulcers improved compared with pressure ulcers in the wet-to-dry dressings group. The hydrocolloid regimen was more efficacious in a subgroup of patients who received inadequate nutritional support during treatment.

Van Rijswijk L. Full-thickness pressure ulcers: patient and wound healing characteristics. Decubitus 1993 Jan;6(1):16-21.
Setting: Acute care, long-term care, and rehabilitation agency
Sample: 119 patients with 153 pressure ulcers
Design: Multicenter prospective, observational trial
Results and conclusions: Of patients whose ulcers improved from baseline, there was a significant reduction in ulcer diameter ($p=0.005$), presence of granulation ($p<0.001$), and presence of necrotic tissue ($p=0.018$). Full-thickness ulcers treated with a hydrocolloid dressing (DuoDERM Hydroactive) did not develop adverse reactions; clinicians perceived the dressing to be efficacious, but no control group was used.

Moist dressings

Bergstrom N, Horn SD, Smout RJ, et al. The National Pressure Ulcer Long-Term Care Study: outcomes of pressure ulcer treatments in long-term care. Journal of the American Geriatrics Society 2005;53:1721-9.
Setting: Nursing facility
Sample: 882 residents
Design: Retrospective observational study

Results and conclusions: Significantly larger area of wound healing with moist dressings ($p<0.001$). Use of moist dressings in stage II, III, and IV ulcers and adequate nutritional support (stage III and IV) are strong predictors of pressure ulcer healing.

Frantz RA, Gardner S, Specht JK, et al. Integration of pressure ulcer treatment protocol into practice: clinical outcomes and care environment attributes. Outcomes Management for Nursing Practice 2001 Jul-Sep;5(3):112-20.
Setting: Long-term care facility
Sample: 46 ulcers
Design: Retrospective, descriptive study
Results and conclusions: Of the 46 incident ulcers treated during the 1-year study period, 40 (87%) healed and 5 (11%) were unhealed when the subject died. One ulcer remained unhealed at the end of the study. The total cost for treatment of these incident ulcers was $18,688, with nursing labor making up 80% of the total expenditures. Adherence to the protocol, which contained predominantly inexpensive moist wound healing treatment options, resulted in complete healing of most pressure ulcers at a relatively low cost to the facility.

Moisture vapor permeable dressing

Sebern MD. Pressure ulcer management in home health care: efficacy and cost effectiveness of moisture vapor permeable dressing. Archives of Physical Medicine and Rehabilitation 1986 Oct;67(10):726-9.
Setting: Home care setting
Sample: 48 patients
Design: Randomized trial
Results and conclusions: Significantly improved rate of healing in stage II pressure ulcers but not significant for stage III ($p<0.05$). The moisture vapor permeable (MVP) dressing improved the healing rate and was more cost effective for stage II ulcers. Both gauze and MVP dressings proved effective for the treatment of stage III ulcers.

Poly-hema paste

Brod M, McHenry E, Plasse TF, et al. A randomized comparison of poly-hema and hydrocolloid dressings for treatment of pressure sores. Archives of Dermatology 1990 Jul;126(7):969-70.
Setting: Long-term skilled care facility
Sample: 43 residents
Design: Randomized controlled trial
Results and conclusions: No significant difference in healing time between the two groups ($p=0.56$). Time to healing was not significantly different between the poly-hema and hydrocolloid dressing groups.

Polyvinylidene film dressing

Takahashi J, Yokota O, Fujisawa Y, et al. An evaluation of polyvinylidene film dressing for treatment of pressure ulcers in older people. Journal of Wound Care 2006 Nov; 15(10): 449-50, 452-4.
Setting: Not available
Sample: 49 patients
Design: Prospective open controlled trial
Results and conclusions: Patients treated with the test dressing showed greater improvement than the patients with conventional dressing and improvement was statistically significant at 12 weeks ($p<0.05$). The PVL film dressing was more effective than conventional treatment in the management of severe pressure ulcers.

Radiant heat/heated dressing

Kloth LC, Berman JE, Dumit-Minkel S, et al. Effects of a normothermic dressing on pressure ulcer healing.Advanced Skin and Wound Care 2000 Mar-Apr;13(2):69-74.
Setting: Spinal cord injury and geriatric units of a VA medical center
Sample: 20 patients
Design: Before-after trial
Results and conclusions: Wounds treated with standard care plus the heated dressing underwent a statistically significant reduction in mean surface area of 60.7%. Wounds in the control group underwent a statistically insignificant reduction in mean surface area of 19.2%. Wounds treated with a radiant heat dressing healed significantly faster than wounds receiving only standard care. There were no adverse effects from the radiant heat dressing.

Thomas DR, Diebold MR, Eggemeyer LM. A controlled, randomized, comparative study of a radiant heat bandage on the healing of stage 3-4 pressure ulcers: a pilot study. Journal of the American Medical Directors Association 2005 Jan-Feb;6(1):46-9.
Setting: Outpatient clinics, long-term care nursing homes, and rehabilitation center
Sample: 41 patients
Design: Randomized controlled trial
Results and conclusions: Eight subjects (57%) in the experimental group had complete healing of their pressure ulcer compared with 7 subjects (44%) with complete healing in the control group (p=0.46). This 13% difference in healing rate between the two arms of the study was not statistically significant.

Saline gauze dressing

Colwell JC, Foreman MD, Trotter JP. A comparison of the efficacy and cost effectiveness of two methods of managing pressure ulcers. Decubitus 1992 Jul;6(4):28-36.
Setting: Acute care hospital
Sample: 70 patients
Design: Randomized, controlled trial
Results and conclusions: No significant difference in treatment efficacy was noted between hydrocolloid dressings and moist saline gauze dressings. While both were equally effective, the hydrocolloid dressings had a lower daily treatment cost than did the moist saline gauze dressings.

Xakellis GC, Chrischilles EA. Hydrocolloid versus saline-gauze dressings in treating pressure ulcers: a cost-effectiveness analysis. Archives of Physical Medicine and Rehabilitation 1992 May;73(5):463-9.
Setting: Long-term care facility
Sample: 39 patients
Design: Randomized controlled trial
Results and conclusions: The cost savings of the hydrocolloid treatment using local wages did not reach statistical significance. However, using national wages, the cost of the hydrocolloid treatment was significantly less expensive. No significant difference between healing times in the two groups (p=0.12). Using national wages, the cost of the hydrocolloid treatment was significantly less expensive.

Soft silicone dressing

Maume S, Van De Looverbosch D, Heyman H, et al. A study to compare a new self-adherent soft silicone dressing with a self-adherent polymer dressing in stage II pressure ulcers. Ostomy Wound Management 2003 Sep;49(9):44-51.
Setting: Nursing home centers
Sample: 38 residents

Design: Open, randomized, multicenter, controlled study
Results and conclusions: There was a significant difference for reduced damage to surrounding skin and dressing removal compared with self-adherent polymer dressing ($p<0.05$). Damage to the surrounding skin, maceration, and dressing removal difficulties were less common with the soft silicone dressing. Differences in tissue damage between the two dressings were significant during weeks 1, 2, and 3 ($p<0.05$). Studies with a larger sample size are needed to confirm these findings.

Sugar and povidone-iodine

Shimamoto Y, Shimamoto H, Fujihata H, et al. Topical application of sugar and povidone-iodine in the management of decubitus ulcers in aged patients. Hiroshima Journal of Medical Science 1986 Jun;35(2):167-9.
Setting: Not available
Sample: 15 patients
Design: Nonrandomized, uncontrolled trial
Results and conclusions: No significant change in size of ulcers treated but a decrease in ulcer odor was noted.

Wet-to-dry dressing

Fowler E, Goupil DL. Comparison of the wet-to-dry dressing and a copolymer starch in the management of debrided pressure sores. Journal of Enterostomal Therapy 1984 Jan-Feb;11(1):22-5.
Setting: Skilled nursing unit
Sample: 10 residents
Design: Controlled trial
Results and conclusions: No significant difference between wet-to-dry gauze and copolymer starch. This preliminary study suggests that treatment with copolymer starch results in more healed pressure ulcers than treatment with wet-to-dry gauze but the difference is not statistically significant.

OTHER ADJUNCTIVE THERAPIES

Decubitus direct current treatment (DDCT)

Adunsky A, Ohry A. Decubitus direct current treatment (DDCT) of pressure ulcers: results of a randomized double-blinded placebo controlled study. Archives of Gerontology and Geriatrics 2005 Nov-Dec;41(3):261-9.
Setting: Geriatric and rehabilitation medicine departments
Sample: 63 patients
Results and conclusions: Randomized, double-blind, placebo-controlled trial. Statistically different time needed for wound closure: 52% longer in placebo ($p=0.03$) compared with treatment. The results suggest that DDCT treatment for stage III pressure ulcers, in addition to conservative wound care, may be useful in accelerating the healing process during the first period of care.

Low-intensity direct current

Carley PJ, Wainapel SF. Electrotherapy for acceleration of wound healing: low-intensity direct current. Archives of Physical Medicine and Rehabilitation 1985 Jul; 66(7):443-6.
Setting: Hospital
Sample: 30 patients
Design: Randomized controlled trial

Results and conclusions: Significantly faster healing rates in the intervention group vs. the control group ($p<0.05$). Study supports enhanced healing with low-intensity direct current treatment.

Monophasic pulsed electrical stimulation

Feedar JA, Kloth LC, Gentzkow GD. Chronic dermal ulcer healing enhanced with monophasic pulsed electrical stimulation. Physical Therapy 1991Sep; 71 (9):639-49.
Setting: Patients at skilled nursing facilities and at home
Sample: 47 patients
Design: Randomized, controlled, double-blind trial
Results and conclusions: Average healing rate of 14%/week in treatment group was significantly better than 8.25% in control group ($p<0.02$). Supports conclusion that high-voltage pulsed electrical stimulation enhances healing of pressure ulcers.

Gentzkow GD, Pollack SV, Kloth LC, et al. Improved healing of pressure ulcers using dermapulse, a new electrical stimulating device. Wounds 1991 Sep-Oct;3(5):158-70.
Setting: 9 study sites
Sample: 40 ulcers
Design: Randomized, controlled, double-blind trial
Results and conclusions: Treated ulcers healed more than twice as much as control ulcers ($p=0.042$). Findings support the conclusion that electrical stimulation enhanced the healing rate of pressure ulcers. Safety of treatment was confirmed.

Ultrasound therapy

Baba-Akbari SA, Flemming K, Cullum NA, et al. Therapeutic ultrasound for pressure ulcers. Cochrane Database of Systematic Reviews 2006 Jul 19;3:CD001275.
Setting: Various
Sample: 146 people
Design: Meta-analysis of randomized controlled trials comparing therapeutic ultrasound therapy with sham ultrasound or conventional treatment
Results and conclusions: No significant differences in healing rates between ultrasound therapy and sham therapy or conventional treatment were found when the studies were pooled together. There is no evidence of benefit of ultrasound therapy in the treatment of pressure ulcers.

McDiarmid T, Burns PN, Lewith GT, et al. Ultrasound and the treatment of pressure sores. Physiotherapy 1985;71(2):66-70.
Setting: Extended care unit of a hospital
Sample: 40 patients
Design: Randomized double-blind trial
Results and conclusions: Infected sores heal more slowly than clean ones. While no effect of ultrasound on clean sores was observed, ultrasound therapy appeared to improve the rate of healing of infected sores. Survival analysis revealed no significant difference in healing times between those treated with ultrasound and those given mock ultrasound.

Ultraviolet (UV) light

Wills EE, Anderson TW, Beattie BL, et al. A randomized placebo-controlled trial of ultraviolet light in the treatment of superficial pressure sores. Journal of the American Geriatrics Society 1983;31(3):131-3.
Setting: Extended care unit of a hospital
Sample: 18 patients

Design: Randomized double blind trial
Results and conclusions: Treated group healed in 6.3 weeks compared with 8.4 for control group; however, this difference was not significant. It appears that UV light may play a useful role in the treatment of pressure sores, and a systematic evaluation of different treatment protocols seems to be justified.

TOPICAL AGENTS, GROWTH FACTORS, AND SKIN EQUIVALENTS

Dermagran dual therapeutic system

Guthrie M, Diakiw J, Zaydon AC, et al. A randomized double blind clinical study of Dermagran dual therapeutic system in the treatment of decubitus ulcers. Wounds 1989 Nov;1(3):142-54.
Setting: Nursing homes
Sample: 128 residents
Design: Randomized, controlled, double-blind trial
Results and conclusions: Treatment was given to 105 patients. At 6 weeks, the active combination group showed a 90.7% improvement in ulcer size compared with 4.8% for placebo, 6.7% active spray alone, and 25.9% active ointment alone. Ulcer area improvement was statistically significant. The combination therapy appeared to show greater improvement in ulcer size than placebo or individual treatments.

Nerve growth factor

Landi F, Aloe L, Russo A, et al. Topical treatment of pressure ulcers with nerve growth factor. Annals of Internal Medicine 2003; 139:635-41.
Setting: Teaching nursing home
Sample: 36 patients with ulcers of the foot
Design: Randomized, controlled, double-blind trial
Results and conclusions: Average reduction in pressure ulcer area was greater in the intervention group receiving the nerve growth factor than in the control group receiving conventional topical treatment ($p=0.034$). Topical application of nerve growth factor may be an effective therapy for patients with severe pressure ulcers.

Recombinant human platelet-derived growth factor-BB (rPDGF-BB)

Robson MC, Phillips LG, Thomason A, et al. Recombinant human platelet-derived growth factor-BB for the treatment of chronic pressure ulcers. Also see Platelet-derived growth factor BB for the treatment of chronic pressure ulcers. Lancet 1992; Jan 4;339(8784):23-5. Annals of Plastic Surgery 1992;29(3):193-201.
Setting: Not reported
Sample: 20 patients
Design: Randomized phase I/II double-blind, placebo-controlled study
Results and conclusions: No changes in blood or serum chemistries. No changes in wound volume with dose 1 ug/ml, 10 ug/ml, or placebo. 100 ug/ml: wound volume 6.4% of day 0, placebo 21.8% ($p=0.12$). No keloids at 5 months. The results of this small, descriptive study suggest rPDGF-BB is a potent vulnerary agent for accelerating soft-tissue repair, warranting further study.

BACTERIAL CONTROL

Acetic acid

Milner SM. Acetic acid to treat *Pseudomonas aeruginosa* in superficial wounds and burns. Lancet 1992;340:61.

Setting: Not available
Sample: 5 patients
Design: Prospective observational study
Results and conclusions: No test of significance. Acetic acid is useful for eradicating surface contaminants of *Pseudomonas aeruginoa*.

Balsam Peru, hydrogenated castor oil, and trypsin (BCT) ointment

Narayanan S, Van Vleet J, Strunk B, et al. Comparison of pressure ulcer treatments in long-term care facilities: clinical outcomes and impact on cost. Journal of Wound, Ostomy and Continence Nursing 2005 May-June;32(3):163-70.
Setting: Nursing homes
Sample: 861 residents
Design: Retrospective cohort study
Results and conclusions: Statistically significant increase in healing rate with BCT. These data suggest that treatment of stage I or II ulcers with BCT may be associated with shorter treatment time and time to heal and a potential reduction in treatment-related nursing labor costs.

Gentamicin (0.1%) cream

Bendy RH, Nuccio PA, Wolfe E, et al. Relationship of quantitative wound bacterial counts to healing of decubiti: effect of topical gentamicin. Antimicrobial Agents of Chemotherapy 1964;4:147-55.
Setting: Medical center
Sample: 20 patients
Design: Randomized controlled trial
Results and conclusions: All 14 pressure ulcers treated with gentamicin improved but only 3 of the patients receiving standard therapy improved ($p<0.001$). There was a statistically significant correlation between healing and amount of bacteria in the wound ($p<0.001$).

Metronidazole

Baker PG, Haig G. Metronidazole in the treatment of chronic pressure sores and ulcers: a comparison with standard treatment in general practice. Practitioner 1981 Apr;225(1354):569-73.
Setting: Medical practices
Sample: 53 patients, 23 with pressure ulcers
Design: Controlled trial
Results and conclusions: There was a significant reduction in pressure ulcer area after treatment with metronidazole ($p<0.04$) There was no significant improvement in pain, odor, or granulation tissue. Metronidazole may help in reduction of pressure ulcer area.

Silver-zinc–allantoinate (AZAC)

Margraf HW, Covey TH Jr. A trial of silver-zinc -allantoinate in the treatment of leg ulcers. Archives of Surgery 1977 Jun;112(6):699-704.
Setting: Ambulatory treatment
Sample: 292 patients
Design: Observational trial
Results and conclusions: Daily use of 1% AZAC resulted in 339 of 400 (85%) ulcers healing. Healing was associated with a significant reduction in wound levels of bacteria.

Silver sulfadiazine

Kucan JO, Robson MC, Heggers JP, et al. Comparison of silver sulfadiazine, povidone-iodine, and physiologic saline in the treatment of chronic pressure ulcers. Journal of the American Geriatrics Society 1981 May;29(5):232-5.
Setting: Hospital
Sample: 45 patients
Design: Randomized trial
Results and conclusions: There was a significant difference in the number of patients who responded to the silver sulfadiazine, compared with povidone iodine (p=0.022). Differences were not significant compared with non-saline gauze-treated ulcers. The number of patients showing clinical improvement was significantly greater for silver sulfadiazine than for povidone iodine.

VACUUM-ASSISTED CLOSURE (VAC)

Argenta LC, Morykwas MJ. Vacuum- assisted closure: a new method for wound control and treatment: clinical experience. Annals of Plastic Surgery 1997 June;38(6):563–76.
Setting: Inpatient and outpatient settings
Sample: 300 wounds
Design: Observational trial
Results and conclusions: Nearly one-third (32%) of pressure ulcers healed completely in 2-16 weeks. Almost half (46%) closed more than 80%. No pressure ulcers recurred at the original wound site. VAC is an extremely efficacious modality for treating chronic and difficult wounds.

Ford CN, Reinhard ER, Yeh D, et al. Interim analysis of a prospective, randomized trial of vacuum-assisted closure versus the healthpoint system in the management of pressure ulcers. Annals of Plastic Surgery 2002 Jul;49(1):55-61; discussion 61.
Setting: Not available
Sample: 22 patients
Design: Prospective randomized trial
Results and conclusions: No significant difference in mean reduction of ulcer volume between VAC and healthpoint. VAC promotes an increased rate of wound healing and favorable histologic changes in soft tissue and bone compared with HP, but differences are not statistically significant.

Smith N. The benefits of VAC therapy in the management of pressure ulcers. British Journal of Nursing 2004;13(22):1359-65.
Setting: Plastic surgery clinics and hospitals
Sample: 281 patients
Design: Randomized controlled trial
Results and conclusions: VAC group showed statistically greater responses in all outcomes measured compared with the control group. VAC therapy was able to heal wounds in a significantly shorter period of time than alginate and hydrocolloid dressings.

Wanner MB, Schwarzl F, Strub B, et al. Vacuum-assisted wound closure for cheaper and more comfortable healing of pressure sores: a prospective study. Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery 2003;37(1):28-33.
Setting: Paraplegic care center
Sample: 22 patients
Design: Prospective study
Results and conclusions: No significant difference between the VAC and wet-wet/wet-dry dressings in healing time or formulation of granular tissue. The two methods were equally effective in forming

granulation tissue. One can profit from the advantages of the vacuum-assisted treatment (reduced costs and improved comfort) knowing that the effect on the formation of granulation tissue is equivalent.

Weed T, Ratliff C, Drake DB. Quantifying bacterial bioburden during negative pressure wound therapy: does the wound VAC enhance bacterial clearance? Annals of Plastic Surgery 2004 Mar;52(3):276-9; discussion 279-80.
Setting: Inpatient and outpatient settings
Sample: 25 patients
Design: Retrospective chart review
Results and conclusions: There is not a consistent effect of bacterial clearance with wound VAC. Furthermore, bacterial colonization increased significantly with wound VAC therapy and remained in a range of 10(4)-10(6). Despite an increase in bacterial colonization from baseline, beneficial effects of this treatment modality on wound healing were noted in most cases.

NEGATIVE PRESSURE WOUND THERAPY (NPWT)

Philbeck TE Jr, Whittington KT, Millsap MH, et al. The clinical and cost effectiveness of externally applied negative pressure wound therapy in the treatment of wounds in home healthcare Medicare patients. Ostomy Wound Management 1999 Nov;45(110):41-50.
Setting: Medicare home health care
Sample: 1,032 patients
Design: Retrospective chart review
Results and conclusions: The 97-day period of healing time expected of NPWT is 61% faster than the 247-day expected healing time for treating similar wounds with saline-soaked gauze. NPWT was more cost effective. Pressure ulcers treated with NPWT for 97 days would cost $14,546 while pressure ulcers treated with saline-soaked gauze would cost $23,465.

Schwien T, Gilbert J, Lang C. Pressure ulcer prevalence and the role of negative pressure wound therapy in home health quality outcomes. Ostomy Wound Management 2005 Sep;51(9):47-60.
Setting: Home health
Sample: Treatment group = 60, nontreatment group = 2,288
Design: Retrospective study
Results and conclusions: Patients receiving NPWT had statistically lower rates of hospitalization than the comparison group ($p<0.05$). To offset potential limitations in generalizability and increase practical application of these results, further research is needed with a larger, nationally representative sample to compare other quality outcomes, as well as the cost of NPWT to other specific wound care modalities.

Tachi M, Hirabayashi S, Yonehara Y, et al. Topical negative pressure using a drainage pouch without foam dressing for the treatment of undermined pressure ulcers. Annals of Plastic Surgery 2004 Oct;53(4):338-42.
Setting: Not available
Sample: 8 patients
Design: Case series
Results and conclusions: Pressure ulcer area decreased in all eight patients. Four ulcers healed completely and no further ulcers developed in the region. Topical negative pressure without dressing is an extremely effective treatment of pressure ulcers complicated by undermining.