

ABSTRACT

The purpose of this pilot study was to evaluate the efficacy and safety of an innovative moist wound dressing in patients following an extensive surgical procedure for pectus excavatum (funnel chest). Forty male patients (age 16-48) were randomly assigned to receive either a moist wound dressing or a standard dry wound dressing. The moist dressing consists of a non-woven fabric coated with a nanolayer of metallic silver containing a zinc/iron (0.003%) wound solution. Wounds were examined immediately following surgery and at 4, 9, and 90 days after application of the dressings and again one year after surgery. The primary measures of efficacy were acute wound healing, rate of infection, crust/scar formation. Patients who received moist wound dressing demonstrated faster time to wound closure than patients in the control group, had no wound infections, and had less crust/scar formation.

SUBJECT CHARACTERISTICS	BIODERM SCIENCES WOUND SOLUTION & DRESSING CARE	STANDARD DRESSING & DRY CARE
Age		
Number	20	20
Mean (Std. Dev.)	19.3 (5.1)	15.5 (1.7)
Range	16-48	16-39
Gender		
Male	20	20

INTRODUCTION

The physiologic processes of wound healing begin immediately upon tissue injury starting with inflammation. The immediate physiological needs include: a moist wound environment, an optimum pH and essential trace elements.

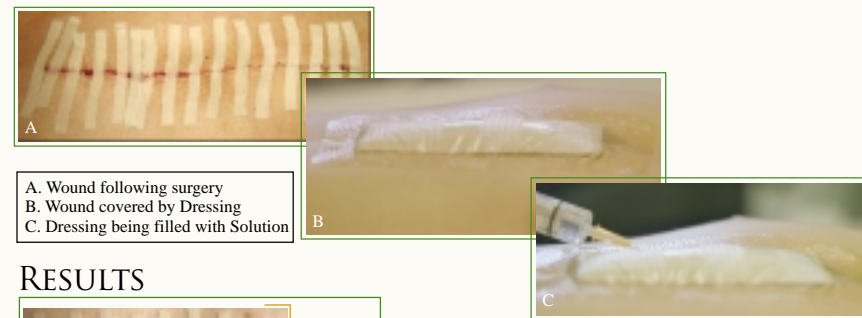
It has been well documented that increased healing rates are associated with moist wound healing versus dry healing. The natural environment of a cell is a moist one and a dehydrated tissue environment may impair normal cell function and repair. Since a wound is a break in the skin, it will allow the escape of moisture vapor from the underlying moist tissues. This process contributes to crust formation along with the drying of released blood and sera. The scab itself presents very little barrier to further moisture loss as compared to normal unbroken skin.

All biochemical reactions, in particular enzyme activities are dependent on a specific pH value. The disturbance of the immediate wound environment starts first with a rise in pH, since the traumatic damaged tissue delivers, due to the disturbed cell respiration, less CO₂ into the tissue. The change of the biochemical reaction conditions connected with acidosis (acidifying the tissue by CO₂-constriction) represents a biochemical condition required for the optimal metabolic sequence and a fast and thorough repair.

Zinc and iron are required substances for various aspects of wound healing. Specifically zinc plays an important role in the activity of different matrix metalloproteinases (MMPs). MMPs are a family of zinc-dependant endopeptidases that cleave peptide bonds of extracellular matrix proteins, such as collagens, elastin and proteoglycans. It has been shown that collagen-degrading MMPs facilitate the initiation of angiogenesis. Newly formed blood vessels participate in granulation tissue formation which is critical in re-establishing skin integrity. Both inflammatory cells and fibroblasts require the interaction with and transmigration through blood vessels to enter the site of injury. An additional two crucial zinc-dependent enzymes involved in tissue repair are DNA and RNA polymerase. These enzymes play a critical role in cell proliferation and protein synthesis for proper wound healing. Other studies have demonstrated that zinc promotes epidermal proliferation and migration. Iron is an essential nutrient, which is utilized by all eukaryotic cells for survival and growth. Iron is required for cell multiplication through the activity of ribonucleotide reductase, an important enzyme in DNA synthesis. Human fibroblasts require iron for *in-vitro* growth and iron is also essential for hydroxylation of collagen. The use of silver to fight infections has been recorded as far back as the ancient Egyptian and Greeks cultures. In low concentrations, silver is highly toxic to bacteria and other microorganisms.

METHODS & MATERIALS

An open, prospective, randomized, comparative clinical study was conducted to evaluate the use of a moist wound dressing in funnel chest surgery at the University of Erlangen, Nuremberg, Germany. The protocol was approved by the University's ethical committee. Control and test groups each comprised 20 patients. The silver dressing (15cm x 8cm) and an acidic, sterile zinc/iron wound solution served as the experimental agent. The dressing consists of a non-woven fabric coated with metallic silver, which is bonded to a conventional polyurethane semi-occlusive medical film. The film protects the wound from abrasion and external contamination and regulates the passage of air to and from the fabric. The fabric containing a silver nanolayer provides antimicrobial as well as anti-adhesive properties thus protecting the wound area from microbial colonization. When a sterile acidic zinc/iron solution is added, the dual layered fabric pad maintains a moist environment surrounding the wound and eases removal of the bandage from the wound. A standard dry wound dressing served as control (Cutiplast steril TM, 15cm x 8cm; Smith & Nephew Medical Ltd, Hull, England). The dressings were applied immediately following pectus deformity surgery which had created a uniform 9 - 11 cm sternal wound. (See Figure A) The sternal area is known to be prone to wound healing complications and scarring. After application of the silver dressing (Figure B), 10ml of a sterile acidic (pH 2.8) solution containing trace amounts of iron and zinc salts (0.003%) were injected into the dressing (Figure C). The dressings of the control and test group were not changed until removal on day 2 and 4, respectively. On day 0, 4 and 9 blood tests (white blood cell count, C-reactive protein) were taken and the wound status was evaluated and documented photographically.



RESULTS



As shown in a previous table, 40 males ranging in age from 16 to 39 years of age were randomized to two clinical groups for evaluation. The accompanying photographs are typical of the results observed with the subjects evaluated at these time points. Visually, the wounds treated with the BioDerm Sciences wound system had less inflammation, less exudates and less open wound than those in the control group. When the wounds were evaluated blindly (see table), the treatment group consistently scored lower in crust and scar formation at all time points. Finally, post surgical wound care costs were significantly reduced in the treatment group.

DISCUSSION

The BioDerm Sciences Wound System demonstrated a sixty percent (60%) faster closure rate when compared to the standard of care and on average reduced the time to closure by 3.1 days to 3.9 days. We believe that this can be attributed to this system directly addressing the dogmas of modern wound care: moist environment, acidic milieu and appropriate nutrition. Potentially in part due to the faster wound closure rate, the infection rate of 0% in the BioDerm Sciences group when compared to the infection rate of <10% with other premier centers utilizing standard regimens, while remarkable, was even more significant by comparison to the standard care control group in this study of 15%. The mean total post surgical treatment cost with the regimen demonstrated a six-fold (6x) improvement in cost by comparison to the regimen. Two factors largely account for this drastic cost reduction: (1) Minimal costs associated with daily care and (2) A zero incidence of infection.

OUTCOME PARAMETER	BIODERM SCIENCES WOUND SOLUTION & DRESSING CARE GROUP	STANDARD DRESSING & DRY CARE GROUP
Time to Closure (in days)		
Mean	3.9	7.1
Range	3.2-4.5	5.7-8.0
Infection Rate (# of patients)	0% (0)	15% (3)
Crust Formation (avg. score)*		
4 Days Post Operation	1.06	2.40
9 Days Post Operation	1.00	2.25
Scar Formation (avg. score)*		
90 Days Post Operation	1.00	2.08
360 Days Post Operation	1.30	2.60
Post Surgical Wound Care Cost		
<i>Administration Cost of Treatment</i>		
Direct Product Acquisition	\$119.00 [§]	\$12.00 [§]
Nurse Administration (thru wound closure)	\$80.00	\$750.00
One Dressing Administration		Avg. Six Dressing Administration
Four reservoir loads		Avg. Six Dressing Debridements
Four syringes/needles		Avg. Six Dressing Removals
One Dressing Removal		
Mean Total Adm. Costs/patient	\$199.00	\$762.00
Total Administration Costs/study	\$3,980.00	\$15,240.00
<i>Mean Adverse Event Treatment Costs</i>		
Infection**	\$0.00	\$700.00/day Additional Hospital Stay Costs Once daily oral antibiotic
Total Adverse Event Costs	\$0.00	\$10,500.00***
Total Post Surgical Wound Care Study Costs	\$3,980.00	\$25,740.00
Total Mean Post Surgical Wound Care Cost Per Subject	\$199.00	\$1,287.00

* Results of independent evaluation of the wound site according to the following scale: 1=none; 2=<10% of wound length; 3=10-20% of wound length; 4=> 40% of wound length
[§] Average Euro to Dollar Exchange Rate during the study period was 1.21
 ** Infection with this procedure results in an additional hospital stay at ~\$650/day
 *** 3 patients with average 5 days hospital extension

CONCLUSIONS

- Decreased time to wound closure
- Eliminated infections
- Reduced scarring
- Reduced post surgical wound care costs