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Clinical aspects of full-thickness wound healing

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Abstract Optimal management of full-thickness wounds requires a thorough knowledge of wound-healing principles and practices. In the absence of underlying disease, almost every full-thickness wound will heal with minimal intervention; however, the process can be enhanced by judicious wound management. The first clinical decision to be made is whether to repair the wound or to allow it to heal by second intention. This decision is guided by a host of objective and subjective factors. Reconstruction options include primary closure, flaps, and grafts. Materials to aid reconstruction, including the introduction of tissue adhesives, continue to evolve. Both primary and secondary intention wounds are aided by occlusive dressings and adjutants. A plethora of wound-healing adjuncts have been developed to aid wound healing in diseased states, and a working knowledge of their use is beneficial in managing all full-thickness wounds.

Introduction

The management of full-thickness wounds is a common part of dermatologic practice. The healing of these wounds is a complicated, coordinated series of events that eventually lead to both a structurally and functionally acceptable result. The initiation of this process is signaled by an insult to the tissues, whether due to an unintentional trauma, such as abrasions, excoriations, blisters, burns, hypothermic injuries, ischemia, or numerous other etiologies, or a defect that has been planned, such as a surgical incision or piercing. The sequence that follows leads to the repair and restoration of the site in question. Numerous growth factors and cell types are involved and are discussed in more extensive detail in other articles contained within this issue. Although the wounds may differ in appearance, time to resolution, and other facets, they still all progress through the same basic stages.[1,2]

Generally, there are 4 stages noted in the healing of any wound: hemostasis, inflammation, proliferation or granulation, and matrix formation or remodeling.[3-6] An understanding of this process allows the clinician to optimize wound healing. These stages are not necessarily chronologically exclusive, but rather a dynamic and integrated coordination of specific processes. These stages can be allowed to proceed uninterrupted, as in healing by secondary intention, or influenced by primary closure with sutures, staples, or adhesives; application of medications or topical products; or placement of various traditional or synthetic dressings. As healing progresses, tensile strength of the wound improves. Wounds have minimal strength during the first week or so of healing, approximately 30% to 50% in 4 to 6 weeks and 60% at around 6 months.[7] Tensile strength slowly increases after this point but usually only reaches a maximum of 80% that of normal, undisrupted skin.

The duration and percentages noted are general guidelines for the time frame and performance expected based on prior studies. Variation does occur due to the type, location, and size of the defect. Clearly, the less invasive, more superficial insults will conclude the entire process more

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rapidly. As appreciated clinically, extremely vascular structures such as the face, or sites closer to the heart, heal at a faster rate. Those more distal, especially the lower extremities, are more difficult to resolve. In addition, it has been found that the healing time for full excisional wounds was linearly related to the surface area, but was unrelated to the depth.[8] Many other factors, including comorbidities, nutrition or prior injury are also contributing variables.

On a more macroscopic level, the physician has the ability to directly influence the healing wound. An obvious management strategy is to surgically repair the wound, known as primary intention healing. Although numerous other options are available, an often overlooked but valuable choice is healing by secondary intention. Secondary intention existed long before the surgical advancements such as flap and graft utilization and ancillary tools that are to be discussed. Another consideration includes a combination of both with partial closure. Numerous adjuncts for primary closing and dressing the sites have been developed and studied. Included are suture materials and adhesives that allow wound edges to remain in proximity while the repair process proceeds. Topical products, including antibiotic ointments, are frequently applied to the sites. There is a multitude of dressing types available for selection to protect the site of repair and maintain an optimal environment throughout the stages of healing. All of the above have their own value depending on the specific wound in question and the desired time frame or outcome.

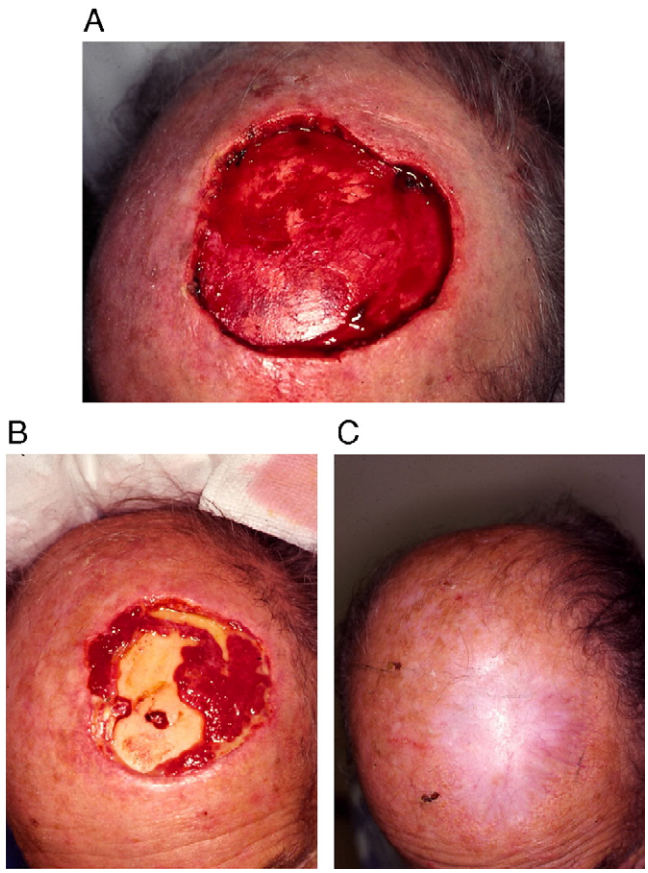

Fig. 1 A, Large, full-thickness surgical defect with exposed bone. B, The defect was allowed to heal by second intention using a simple bandage and antibiotic ointment. C, With complete healing and a reasonable cosmetic outcome.

Full-thickness healing

As a rule, in the absence of underlying disease, most wounds left without intervention will eventually heal by secondary intention (Fig. 1). Failure to take advantage of this property is more common now than in the past. Concerns over complete healing, scar formation, effects on noninvolved, adjacent tissues, infection rates, and location all limit its consideration. This is more an error of perception of frequency than actual common, documented complications. As more options became available through surgical experience and technological advancement, loss of appreciation for secondary intention developed.[9] Although valuable for use in multiple situations, this mode of healing is not a panacea. The appropriate decision regarding when and in what context to allow secondary intention healing, rather than the other available options, must still be made.

Larger, more extensive defects are often closed with grafts or flaps instead. Grafts are portions of tissue containing epidermis along with different percentages of the dermis. Full-thickness skin grafts include the entire dermis with sweat glands, hair and sebaceous units, and vascular structures. Split-thickness skin grafts are those with anything less than the entire dermis. Although grafts are often used to prevent the contracture seen in secondary intention healing, grafts also demonstrate contracture. Primary contracture is a condition in which a graft demonstrates immediate recoil after harvest due to the elastin within the dermis. The more dermis that composes the graft, the more primary contracture will result. Secondary contracture is the delayed, gradual contraction seen with a healing graft, most likely due to myofibroblast activity and cellular repair. A full-thickness skin graft demonstrates greater primary contracture and less secondary contracture. Split-thickness skin grafts, in contrast, are less prone to primary contracture but more to secondary contracture. The thinner the split-thickness graft is, the more pronounced the secondary contracture becomes. Secondary contracture is the more problematic property of the two regarding functional and cosmetic results. Grafts have no blood supply once harvested and, therefore, rely on simple diffusion from the wound bed after relocation. Over the next several days after placement, grafts go through phases of nutrient absorption, vascular realignment, and establishment of an intact vascular supply that grows from within the bed. Survival of the graft depends on its ability to secure this vascular network without compromise. Therefore, excess noncontributory tissue must be removed from the graft and

the recipient site must be optimized with close contact upon a vascularized bed. The most common causes of the graft failing to survive have been noted to be the accumulation of serous fluid or blood between the graft and the bed as well as infection of the site itself. In summary, split-thickness grafts have a higher survival rate due to their reduced thickness and greater diffusion capacity, but an inferior cosmetic outcome compared with full-thickness grafts.

Flap repair

Flaps are another option for closing certain skin defects. A flap is an epidermal, dermal, and subcutaneous unit with a native vascular supply remaining connected for nourishment, which is the primary benefit over grafts. Flaps based on a known arterial blood supply are known as axial flaps. Their shape and orientation is based on an available, underlying vascular supply. Dermatologists most often use random pattern flaps that do not contain a defined blood supply. In addition, their orientation and shape is primarily defined by the defect to be filled rather than by the vascular source. Flaps are named for the vector of their primary motion: advancement, rotation, or transposition. They may also be "free" flaps, excised units of skin and deep tissue in which the vascular supply is still a part of the flap but is temporarily transected then reestablished at a more distant location to a new vascular source. Flaps are valuable to redirect tension away from the wound itself to more favorable sites when poorly or nonvascularized sites are in need of coverage or when additional tissue mass is desirable for padding delicate areas. Compared to grafts, there is less concern of complications from fluid collections and infection but more concern of ischemic damage secondary to pedicle compromise.[10]

When securing flaps or grafts or closing wounds primarily, suture is most commonly the method of choice, although staples are sometimes used for efficiency. The selection of the suture material and its properties is an important decision along with the other choices of management.

Suture material

Several terms are used in the description of suture materials. Elasticity is the ability of the suture to retain its original length after stretching. Plasticity is demonstrated by suture material that will not return to the original length after being stretched. The ability to return to the original shape after manipulation is termed memory. Such material is often stiff, less likely to retain a placed knot, and more difficult to work with.[11] The tensile strength is the amount of weight required to break the material divided by the cross-sectional area. These are seen as designations of 0, 1-0, 2-0, etc, and the larger the first number, the weaker and smaller caliber the material. Knot strength is a measure of the force required to cause a knot to slip after being placed. The coefficient of friction of the suture material has a direct effect on the knot strength and the ease with which the suture glides through the tissues. Suture line can be either a monofilament or a multifilament that is twisted or braided.

Another property to consider when choosing a suture is the type of absorbable or permanent product to use. Absorbable sutures typically lose most of their tensile strength within 60 days of placement. Traditionally, these are most often used for deep approximations, but some clinicians also suggest using them superficially for facial lacerations, areas inaccessible for removal, mucosal surfaces, finger repairs, and nail beds.[12-18] Catgut is an absorbable material produced from cattle or sheep intima. Tensile strength remains intact for 5 to 7 days or, if treated with chromium, extended to around 10 to 14 days.[19] Vicryl (polyglactin-910) retains its strength for approximately 3 to 4 weeks and is often chosen for deep suturing because of this time frame. Monocryl (poliglecaprone 25) is a synthetic monofilament that will retain tensile strength for 21 days on average. Dexon (polyglycolic acid) is a synthetic, absorbable suture that maintains at least 50% of its strength for 3 or 4 weeks.[20] PDS (polydiaxanone), another monofilament synthetic, is longer lasting, able to retain most of its tensile strength for 5 to 6 weeks. Maxon (polytimethylene carbonate), a third synthetic monofilament, also maintains most of its strength for 5 to 6 weeks.

Nonabsorbable suture is primarily used for external closures; however, exceptions are present within the surgical specialties.[21] Silk is a natural fiber and is the weakest option available. It is soft, and thus useful in areas such as the lips and eyes where rigid suture ends could "poke" the patient. Use of silk has largely been replaced by the use of synthetics that are similarly soft. Dermalon or Ethilon (nylon) is an easily manufactured synthetic that has excellent strength but is also quite elastic. Surgilene or Prolene (polypropylene) is a synthetic plastic fiber also with great strength, but its distinctive quality is its plasticity. Stainless steel is also available as a suture material.[22] Each of these sutures has its own benefits and limitations but when used in the appropriate settings, along with the knowledge of experienced clinicians, they are all valuable options.

Tissue adhesives

A more recent advancement for the approximation of skin wounds, optimally those that are almost linear or demonstrate minimal or no tension, is the development of tissue adhesives.[23-26] These chemical bonding agents have been used in other countries for several years but were only approved for use in the United States as recently as 1998.[27,28] The only product available in this country is marketed under the name Dermabond (octyl-2-cyanoacrylate) and is thus the most commonly used. Histoacryl (butyl-2-cyanoacrylate) is available in other countries, but it

forms bonds that are not as strong and produces higher levels of the irritant by-products cyanoacetate and formaldehyde. Once applied, the tissue adhesives undergo an exothermic reaction that bonds the wound edges maximally in approximately 2.5 minutes. Proponents of adhesives note several advantages over traditional suture use.[29-31] Time to complete closure of the wound is generally much faster.[32] This is certainly an advantage when dealing with the pediatric or uncooperative patent. Another benefit is the avoidance of further anesthesia requirements because there is typically little or no pain involved with the application. Comparing the side effects and complications, little difference is found between adhesives and sutures. A systemic database review did find a minimal but significant increase in wound dehiscence with adhesives, but the clinical significance has not been demonstrated. No individual study has shown an increase in the complication rate.[33] An important consideration for both the physician and patient is the cosmetic outcome of the procedure. Studies have shown that there is no significant difference in cosmesis between the tissue adhesives and closure by the traditional manner with sutures. In fact, some studies report that the results are actually better if the chemical polymers are used. It is also more financially advantageous to use the adhesives. Cost savings are realized because there is no expense related to follow-up visits with the associated staff hours, loss of other scheduled patient time, and the disposable or sterilized equipment involved as when using sutures.

With all the benefits noted above, tissue adhesives are not appropriate for all wounds. Use is primarily for clean, linear sites that could also be closed with smaller caliber sutures. There have also been examples of the use of acrylic as a dressing substitute over small sutures.[34] Areas of complex tissue disruption or of high tension are not recommended for consideration. Often excluded examples include hands, feet, joints and chest or back if movements that greatly increase skin tension are encountered. More specific sites to avoid are mucosal surfaces, vermilion borders, hairlines, puncture or bite wounds, or areas of other contamination. Studies also recommend avoidance in those with vascular disease, diabetes mellitus, peripheral vascular disease, steroid use, sites of bleeding, decubitus ulcers, or allergies to components of the adhesives or the resulting degeneration products.[35] Subcutaneous sutures may or may not be used before application of the chemical tissue adhesives.

When there is an indication for use, the area must be cleansed just as any other wound that is to be repaired. The edges of approximation must be brought together with a slight eversion if possible. Then the application capsule must be squeezed to break the internal, chemical-containing vial. The liquid must then be painted over the wound edges in a single, gentle motion. For maximum polymerization to occur, the edges should be held together for at least 30 seconds; optimal strength is attained at 2 minutes. This process is repeated 3 to 4 times, extending the total area of coverage to 5 to 10 mm from the wound and allowing more time to dry with each application. Petroleum jelly, antibiotic ointment, or acetone may be used to remove the dried product should that be necessary.[36] These may also be used as a protective barrier surrounding the application site to prevent runoff and protect adjacent sites. After completely dried, the site needs no further intervention. Dressings may be used but are not necessary and antibiotic ointments should be avoided to prevent polymer degradation. Extensive scrubbing or soaking should also be avoided for 7 to 10 days but showering is acceptable. The acrylic will gradually peel off by itself within 5 to 10 days, with no follow-up necessary unless indicated.[37,38] If the adhesive becomes removed before optimal healing, as determined by the physician, reapplication or use of sterile adhesive tapes are quite acceptable options to allow further time for healing. Just as with sutures, with appropriate selection of their use, chemical tissue adhesives are a very valuable option for wound closure.

Wound dressing materials

After a wound has been managed by a given closure technique or left to heal by secondary intention, the next decision is what should be used in addition. This would include topical products and dressing materials. Most commonly, an antibiotic or antiseptic ointment is used, although this may not always be necessary and may in fact be harmful. As an example, a traditional antiseptic, provodine iodine, has been shown to inhibit wound healing. The newer formulation of this product, cadexomer iodine, however, is a slow-releasing iodine that is nontoxic. It has been shown to be specifically useful for venous leg ulcers.[39-42] Studies have proven it to be effective for a broad coverage of organisms including *Staphylococcus aureus*, β-hemolytic *Streptococcus*, *Proteus*, and *Klebsiella*.[43] Silver-containing preparations are also used as topicals, such as Silvadene, or as dressings impregnated with silver compounds. Silver blocks the bacterial respiratory enzymes, leading to effective killing of a broad spectrum of flora. This includes methicillin-resistant *S aureus* and vancomycin-resistant *Enterococcus*.[44,45] Both the silver- and the iodine-containing therapies have been incorporated into effective slow-release dressing products.

Hydrogen peroxide is yet another commonly encountered topical application. The bubbling seen with its use, a reaction with the enzyme catalase, provides a cleansing effect for crusts, excess scabbing, and other accumulated debris. However, it has been shown to possibly impede wound healing because it has inhibitory effects on fibroblasts and local vascular circulation.[46] A similar problem is anticipated with the topical antiseptic Dakin's solution (sodium hypochlorite). It has very broad and effective antimicrobial activity, even destroying HIV. Its effectiveness is primarily for debridement of necrotic tissue and

occasional cleansing. This solution should not be used as a primary agent because it also inhibits wound healing. It has been demonstrated that wound strength is decreased and there is impaired epithelialization, fibroblast activity, and overall cellular survival. Therefore, use should be minimized with routine wounds and tailored only to specific uses.[47-51]

There are numerous other topical alternatives. Included are polysporin, neomycin, bacitracin, neosporin, mupirocin, erythromycin, clindamycin, and others.[52-55] Most often, the postoperative choice of topical antibiotic is either bacitracin or polysporin. Neomycin, although widely available, has often been avoided because of a suggested increased incidence of contact dermatitis. In patients who tend to develop contact dermatitis, neomycin is a common precipitating allergen. However, most patients encountered do not develop such a reaction. There is a small incidence of cross-reactivity with bacitracin and neomycin and although there is potential, this is not commonly problematic.[56] Alternatives for those allergic to bacitracin are erythromycin, mupirocin, or others. Mupirocin (Bactroban) is often used in the treatment of nasal *Staphylococcus* colonization, but the effectiveness of that indication has been questioned. In an article by Smack et al,[57] a comparison was performed between bacitracin and white petrolatum (Vaseline). It was reported that in ambulatory patients, there were no significant safety concerns, a low, comparable rate of infection, no noted allergic reactions, and no difference in rate or quality of wound healing when using the petroleum jelly.[57] It is becoming an equally accepted choice of topical treatment because of these properties and the ability to keep the healing wound moist. As noted, there are numerous other antimicrobial options available but those discussed above are some of the most frequently encountered.

Wound healing adjuncts

It has long been observed that the skin of older individuals heals more slowly and less optimally than that of their younger counterparts. One defining point at which healing differences occur is that of pre- and postmenopause. This is in part due to the lower concentration of estrogen reaching one of its end organs, the skin. These low levels lead to impaired signal transduction, unregulated inflammation, and protein balance alteration, causing excessive leukocytosis and decreased matrix deposition. Some studies note that local and systemic estrogen application increase collagen content, dermal thickness, and elastic properties. Estrogen has also been noted to be a systemic and local anti-inflammatory, decreasing the multiple proinflammatory cytokines including macrophage migration inhibitory factor.[58-61] Some studies argue the beneficial effects and improved results with the use of systemic hormone replacement or oral contraceptive pills rather than topical preparations.[62] The topical use of estrogen, however, has been shown to confer definite benefit and warrants more extensive study and determination of optimal use.

As noted before, wounds heal better in a moist environment, especially in the presence of its own serous fluid. This led to the investigation of growth factors such as platelet-derived growth factor (PDGF). PDGF was approved for clinical use in 1988 and studies have shown benefit in wound healing, with some noted to be in a dose-related manner. Most of these studies have been done on diabetic wounds, often using vehicles containing PDGF-encoded adenoviruses. The concentration of other growth factors increases, neovascularization is more pronounced, collagen production is more robust (one study notes as much as 3.5 times higher than untreated wounds), and the collagen deposited demonstrates more organization. Specifically, PDGF-D increases macrophages and overall cell density and aids in vascular maturation. The safety of growth factor therapy has also been studied. There were no deleterious changes in chemical, hematologic, or histologic presentation. Adenovirus particles were noted locally within the wound and distally within nodes but not in the blood or other organs. In addition, an IgG response is reported but it is well tolerated with no immunologic or autoimmune side effects.[63-69] PDGF is a safe, effective consideration for promotion of venous wound and other full-thickness wound healing.

Another option in the care of a healing wound is the use of occlusive dressings. There are several advantages to the use of such products. One major benefit is the creation and maintenance of a moist environment.[70] This has been proven to aid in wound healing rates by decreasing desiccation, eschar formation, and inflammation as well as allowing accumulation of growth factor–rich exudate that promotes epithelialization.[71-75] Some studies have shown a 4% to 5% increase in healing rate for venous stasis ulcers, 20% to 30% increase for skin grafts and Mohs procedure sites, and up to a 50% increase for dermabrasion sites. It is also a physical barrier that offers additional protection and helps to exclude bacteria.[76] The pressure introduced by placement assists in hemostasis and the prevention of seromas or hematomas. Wound debridement is more effective when done on a moist, occluded site. There is also a decrease in pain that has consistently been found. This is likely due to several factors including those above. The mental security provided by the dressing is also very beneficial. Patients are more comfortable with the site itself; in addition, the dressing is appropriate for exposure in social settings. A further advantage to occlusive dressing use is the cost-effectiveness. The dressing itself is more costly, but when the time and multiple changes of individual dressings, such as wet to dry, are considered, the cumulative cost is less. Overall, it has been found that there is at least a 50% saving from occlusive vs traditional dressings.[75,77,78]

The primary concern noted with using these products is the increase in bacterial growth.[79-81] This is thoroughly documented and has been demonstrated by bacterial growth

counts frequently above the defined level of 10^5 colonies per gram tissue.[55,81-85] This increase is accompanied by a shift to more gram-negative flora.[81,86] This finding, however, must be distinguished from that of a true infection. Colonization is not the primary concern. The focus is on an area that demonstrates the classical signs of infection such as pain, swelling, erythema, or warmth. Multiple studies have shown that although there is an increase in bacterial count there is not a higher rate of clinical wound infection.[86-90] Synthetic, occlusive dressings, therefore, are an extremely beneficial adjunct to wound care.[91-93] Specific examples would include the polymer films, polymer foams, hydrocolloids, hydrogels and alginates, among others.

Polymer film dressings are polyurethane or copolyester biosynthetics with an adhesive backing. They are permeable to oxygen and carbon dioxide as well as water vapor, but occlusive enough to retain wound fluids and prevent introduction of bacteria. Most often the types of wounds to which they are applied are intravenous catheter sites, partial-thickness wounds, burns, postoperative laser sites, decubitus ulcers, skin graft donor sites, and Mohs surgical defect sites.[94-99] Drawbacks to the adhesive backing are poor adherence, creation of a portal for bacterial entry, interference or stripping of the wound bed, and serous accumulation or leakage.[100] There have been advances and alterations of these dressings recently to reduce the incidence of these events.

Polymer foam dressings consist of an inner, absorbable polyurethane layer and an outer, semiocclusive polyurethane, polyester, Gore-Tex, or silicone outer layer.[101-106] These dressings are most commonly implemented in venous ulcers, Mohs defects, dermabrasion or other cavitary lesions.[104,105,107] Concerns with this option are that of adherence, limited absorptive capacity, use limited to moist areas, and the requirement to change the dressing every 1 to 3 days.[106]

Hydrocolloids are composed of ethylene vinyl acetate, styrene isoprene, or polyisobutylene (all for adhesion), along with a hydrophilic colloid base of pectin, carboxymethyl cellulose, karaya, or quar and an outer polyurethane or similarly impermeable layer.[76,106] Common uses for hydrocolloids are for venous ulcers, pressure ulcers, bullous disorders, burns, partial-thickness injuries, dermabrasion sites, and cushioning to prevent pressure or friction lesions.[108-117] There are disadvantages to the use of this dressing material. There is frequently an odor associated with the gels, and leakage or maceration often occurs if excess exudate accumulates. In addition, the gel left behind when changing the dressing can be confused with a purulent, infected wound. Irrigation with saline should clear the material and allow determination of true site appearance.[82,100,118] Although less common, it is possible that the adhesive may cause disruption of epithelium with removal of the dressing.[119]

Hydrogels are composed of water, usually greater than 90%, combined with polymers such as polyvinyl alcohol, polyacrylimide ,or polyethylene oxide and a supportive mesh or film. It is permeable to oxygen and can absorb a significant amount of wound exudates. Documented uses of hydrogels include split-thickness wounds, hair transplants, dermabrasion, chemical peels, ulcers, thermal burns, postoperative laser sites, and friction blisters.[71,106,120,121] The high specific heat affords a cool, soothing coverage to these wounds.[122-125] As with some of the other dressings, there is an increase in bacterial count, specifically gram-negatives, but no increase in infection rates.[71,86]

Alginates are dressings consisting of polysaccharides derived from kelp such as *Macrocystis pyrifera* and *Laminaria digitata*. It is obtained as a sodium salt, and ion exchange with calcium or zinc is commonplace. Although these materials are one of the least studied, there are publications noting their value.[75,126-130] A very valuable property is the hemostatic ability of the dressing. This is attributed to the calcium ion exchange with the sodium ions of the wound bed, promoting the clotting cascade.[131-134] Maintaining a moist environment is also a benefit because the dressing absorbs exudates and transforms into a gel-like consistency.[135] Most often the alginate dressings are used on chronic ulcerations, Mohs surgery defects, partial or full-thickness burns, ingrown toenails, pressure sores, or other exudative sites.[75,113,136-139] Negative aspects of this choice in dressing material include the following: no adhesive backing requiring a secondary dressing, occasional maceration of skin, possible drainage from highly exudative sites, increased bacterial counts without true infection and, as with hydrocolloids, a purulent appearing malodorous gel that may lead to the mistaken assumption of infection.[89,106,118]

Use of a vacuum-assisted closure device has become a popular adjunct to chronic wound management as well. The basis of this device is that it establishes a subatmospheric, negative pressure environment (optimally 125 mm Hg) for the wound. This has been demonstrated to more quickly reduce the surface area of wounds by increasing blood flow and increasing cell division and, thus, the formation of granulation tissue, as well as decreasing edema and exudate collection.[140] As with other dressings, the bacterial count is altered. However, there is a decrease, rather than an increase, in gram-negative organisms, along with an increase in *Staphylococcus* growth.[141] Neither of these changes leads to clinical infection or negatively affects the wound site. Because the device has been so beneficial, multiple applications have been noted that include chronic wounds, fasciitis, postsurgical sites, diabetic wounds, areas of exposed hardware, peripheral vascular disease, spina bifida, skin graft recipient sites, venous stasis ulcers, decubitus ulcers, and others.[142-146]

Probably the most frequently encountered dressings would be the Telfa pad or Band-Aid, which are absorptive pads covered by a perforated plastic membrane.[106,147] These products are most commonly used for abrasions, biopsy sites, small incisional wounds, Mohs surgery defects, superficial burns, blisters, or mildly exudative wounds.[148]

The limiting aspects of these dressings include the minimally or nonadherent design that often requires additional reinforcement, the limited absorptive capacity requiring more frequent changes, and a generally limited area of coverage.[148,149] Overall, however, these dressings are a very valuable and simple option for many wounds that are more commonly encountered.

Conclusions

Most full-thickness wounds seen by dermatologists are created surgically. In the absence of underlying disease, the great majority of full-thickness wounds will heal without extraordinary intervention. However, knowledge of wound healing principles and practices can greatly enhance the process. The most fundamental decision to be made for a full-thickness wound is whether to repair the wound surgically or to allow it to heal by second intention. There are absolute and relative indications for repair. Preservation of function is a mandatory indication for repair. For example, a functional eyelid is mandatory after eyelid surgery to maintain vision. Scars will contract up to 40% of the size of the original wound, and if such contracture produces a functional deficit, then repair is mandatory. Examples include wounds near the eye or mouth that may produce ectropion and eclabion, respectively, or a wound of the ear canal where contracture may produce stenosis or occlusion of the canal. For wounds where reconstruction is not mandatory, the need and wisdom of pursuing reconstructive surgery requires consideration of a number of objective and subjective factors. What is the likely result given the size and anatomic location of the wound? What are the patients' concerns and expectations? Are they concerned about the cosmetic outcome? Can they tolerate any further surgery? Can the patients perform weeks to months of wound care for second intention healing? Some general principals of second intention healing can help guide the decision. As a general principle, concavities heal quite nicely, with a pleasing aesthetic result, whereas convexities do not. For example, a small wound of the concave inner canthus will heal very well by second intention, whereas the cosmetic result of the convex nose will not be so pleasing after second intention. Wounds of the lower leg will take very long to heal, so repair may be indicated to prevent months of wound care.

Partial repair is a middle path that alters the dynamics of wound healing. A round surgical wound will give an atrophic round to stellate scar if allowed to heal by second intention. However, if the round wound is converted to an elliptically shaped open wound, the dynamics of scar contracture often result in a linear scar that can approximate the appearance of a wound that was completely sutured shut (Fig. 2).

Irrespective of whether a wound is repaired or allowed to heal by second intention, it is beyond scientific question that occlusion speed healing provides greater comfort and may give a better final cosmetic result. Simple occlusion with an antibiotic containing petrolatum ointment and a semiocclusive bandage is typically all that is required. Literally hundreds of special dressing materials are available for

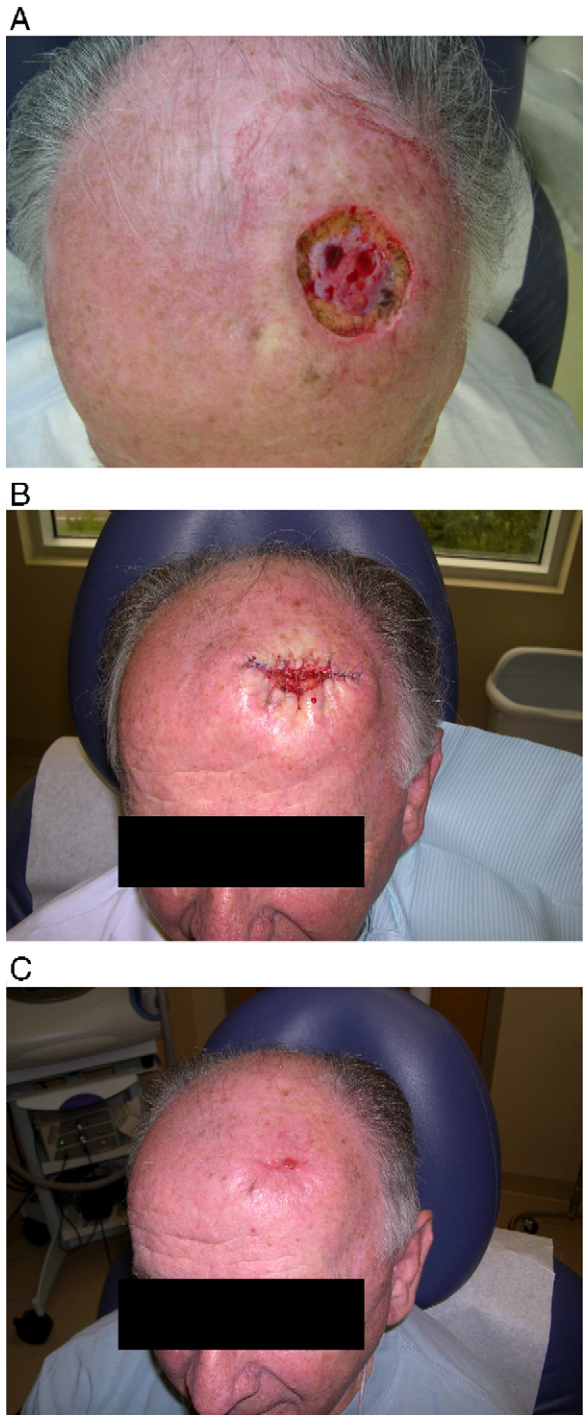

Fig. 2 A, Surgical defect of the forehead and frontal scalp after skin cancer excision. B, The defect is too large for primary closure, so partial closure of the defect was performed. C, Final result with scar contracture optimized to give the appearance of a complete primary closure.

problem wounds such as venous leg ulcers or diabetic foot ulcers. The choice of which system to use for problem wounds is based on the special characteristics of the individual wound, the surrounding skin, and the patients themselves. Thorough knowledge of wound healing and management strategies allows the clinician to make the optimal choice for each patient.

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