A Review on the Recent Developments in Wound Dressing Materials

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Abstract

The use of biomaterial as wound dressing material is currently undergoing a renaissance in the tissue engineering field. The biotechnological applications focus on the aspects of cellular growth or delivery of proteins capable of stimulating cellular response. The excellent biocompatibility and safety due to its biological characteristics such as biodegradability and weak antigenicity made wound dressings as the primary resource in medical applications. Currently, there is a variety of wound dressings available ranging from passive adherent/nonadherent to interactive and bioactive products that contribute to the healing process.Many of the newer dressings are designed to create a moist wound healing environment which allows the wound fluids and growth factors to remain in contact with wound, thus promoting autolytic debridement and accelerating wound healing. Even with substantial advancements in wound dressings it appears that no single material can produce the optimum microenvironment for all wounds or for all the stages of the wound healing process. The intent of this report is to provide a review of currently available dressings, and to describe their best use as it relates to the condition of the wound and the phases of wound healing.

Keywords: Wound Dressings, Adherent, Nonadherent, Occlusive and Semiocclusive

Introduction

The important parameters of an "ideal wound dressing" include its ability to absorb exudates and toxic components from the wounds surface, maintain a high humidity at the wound/dressing interface, allow gaseous exchange, provide thermal insulation, protect the wound from bacterial penetration,be nontoxic and be removed easily without trauma to the wound [1]. Criteria that were added later included that the material should have acceptable handling qualities (resistance to tear and disintegration when wet or dry), and be comformable and be sterilizable [2].

Many of the newer dressings are designed to create a moist wound healing environment which allows the wound fluids to remain in contact with wound. The concept of moist wound healing has been around since the 1960s,[3] but only recently has become a more accepted treatment approach in the veterinary community [4].A moist wound free of infection provides an environment rich in white blood cells, enzymes, cytokines and growth factors beneficial to wound healing [5]. The enzymes released primarily from the white blood cells cause autolytic debridement of the wound which appears to be selective for necrotic tissue [6].Under these dressings autolytic debridement usually occurs 72 to 96 hours after wounding; thus cleaning the wound in preparation for the repair phase. Fibroplasia (fibroblast migration, proliferation and secretion of ground substance) and epithelialization are stimulated by growth factors present in the moist wound [7]. Cytokines which are signaling peptides also act locally to stimulate the migration and activation of macrophages and neutrophils within the wound [8].Proposed benefits to moist wound healing include, prevention of the formation of a scab

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which can trap white blood cells which prevents them from participating in their important wound healing functions, the pH of the environment is reduced, thus adversely affecting bacteria, prevention of bacterial strike through from outside the wound to the wound surface,more rapid epithelialization, and the moist environment favors colonization of bacteria but not infection.

Many natural polymers and their synthetic analogues are used as biomaterials, but the characteristics of collagen as a biomaterial are distinct from those of synthetic polymers mainly in its mode of interaction in the body [9]. Collagen plays an important role in the formation of tissues and organs, and is involved in various functional expressions of cells. Collagen is a good surface-active agent and demonstrates its ability to penetrate a lipid-free interfsace [10]. Collagen exhibits biodegradability, weak antigenicity [11] and superior biocompatibility compared with other natural polymers, such as albumin and gelatin. The use of collagen as a drug delivery system is very comprehensive and diverse.

The purpose of this report is to provide a review of few currently available dressings and to describe their best use as it relates to the condition of the wound (clean, contaminated or infected) and the phases of wound healing.

Wound Dressings

Wound dressings have been broadly classified as either adherent or nonadherent and absorbent or nonabsorbent [12,13] Adherent dressings are frequently made from closely woven or widely open gauze, other cotton materials or wool and under most circumstances are considered passive; although a few are considered interactive. Nonadherent dressings have variable absorbency and are subdivided into occlusive, semiocclusive and biological types.

Absorbent/Adherent and Non-Adherent Dressings

Absorbent dressings can either be of the fibrous type (eg, cotton anfd cellulose wadding) or fabric type (eg, gauze) or a combination of fibrous and fabric (eg, Gamgee™). Many, but not all of the absorbent dressings, adhere to the wound surface which affects wound debridement. This section will focus on the types of dressing used most frequently in equine practice.

Natural Particulate and Fibrous Polymer Dressings

This group of dressings includes naturally occurring products from a range of polysaccharide materials such as dextranomes [14], alginates and chitin. In general, these dressing are highly absorbent (hydrophilic) and best used during the inflammatory and debridement phases of wound healing.

Calcium Alginate

Calcium alginate dressings are classified as a fibrous dextranomer.They are available from a variety of sources (Curasorb® Ken Vet, Greeley, CO; C-Stat® R S. Jackson Inc., Alexandria, VA, Nu-Derm® Johnson & Johnson Products Inc, New Brunswick, NJ). They are made from salts of alginic acid obtained from algae Phaeophyceae found in seaweed. Since the dressing is hydrophilic it can absorb up to 20 to 30 times its weight in wound fluid. This process converts the initial dry felt like material into a hydrophilic gel on the wound surface that is easily removed. The hydrophilic alginate gel forms via a calcium and sodium ion exchange, providing a moist environment conducive to wound healing [15].The presence of calcium modifies cell response. All concentrations of calcium produce an initial fall in cell replication, however the intermediate concentrations subsequently stimulate cell division. Reportedly the dressing increases epithelization and granulation tissue formation. This was not found in one study done in horses [16].

Chitin (Ch)

Ch is a polymeric N-actyl-D Glucosamine that is a component of the skeletal material of crustaceans and insects. It is made into various forms, including sponge, cotton, flakes and nonwoven fabric. One subjective clinical study reported on the use of C for the treatment of various types of wounds, abscesses, surgical defects and problematic herniorrhaphy in 147 cases. Reportedly there was good healing in 89.5% of cases where the sponge was used, 87.5% of cases where the nonwoven fabric was used, 90% when the cotton form was used and 88.9% when the flake form was used to treat the various wounds [17].

Occlusive and Semi occlusive Synthetic Dressings

Hydrogels (Polyethylene Oxide Occlusive Dressings)

Hydrogels are a three-dimensional network of hydrophilic polymers with a water content between 90 and 95%. [15] They are made from such materials as gelatin or polysaccharide which is cross linked with a polymer.

Hydrocolloid

Hydrocolloid dressings consist of an inner often adhesive layer, thick absorbing hydrocolloid "mass" and an outer, thin water resistant bacterial impervious polyurethane film. The hydrocolloid mass is either made of gelatin, pectin and carboxymethylcellulose particles suspended in polyisobutylene or carboxymethylcellulose particles embedded in an elastotic mesh [18].

Silicone Dressings

Investigation on the efficacy of silicone gel dressing in preventing the development of exuberant granulation tissue in distal limb wounds in horses were reported in earlier studies. It was observed that the silicone dressing greatly surpassed a conventional non- adherent absorbent dressing in preventing the formation of exuberant granulation tissue in experimental wounds in horses. Contraction and

epithelialization progressed faster in the first two weeks of repair, possibly as a result of the healthier granulation tissue. Furthermore, tissue quality exceeded that of wounds treated conventionally. A silicone gel dressing is commercially available (Silastic gel®, Dow Corning Corp, Midland, MI) The product has been shown to be efficacious in both prevention and treatment of hypertrophic scar in humans [19].This would imply the gel may also be beneficial in the prevention and treatment of exuberant granulation tissue.

Antimicrobial Dressings

Infection and bacterial colonization remain very important factors in delayed wound healing. Since the wide spread use of systemic and topical antibiotics has resulted in increasing numbers of resistant bacterial strains (eg, methicillin-resistant Staphylococcus aureus and vancomycin resistant Enterococcus faecalis and Pseudomonas aeruginosa) it has been suggested that the judicious use of antimicrobial dressings,notably those containing certain antiseptics, can be important in infection control and in promoting healing [20].

Iodine Containing Dressing

A commercially available iodine dressing (Iodosord® Smith& Nephew, Hull, UK) is manufactured from cross-linked polymerized dextran which contains iodine. As the dressing hydrates in the moist wound environment, elemental iodine is released to exert an antibacterial effect and to interact with macrophages to produce TNF-α and IL-6 which can indirectly influence wound healing [19].

Biologic Dressings

Biologic dressings are developed from natural products produced by the body. Reportedly they promote wound contraction and epithelialization by retarding the formation of exuberant granulation tissue and they are considered bioactive.

These are derived from natural tissues usually consisting of various formulations and combinations of collagen, elastin and lipid [21]. They are far superior to synthetic dressings [22] in that they

1. restore a water vapour barrier and prevent dehydration of the wound;
2. decrease evaporational heat loss;
3. decrease protein and electrolyte losses in wound exudate;
4. prevent bacterial contamination of the wound and hence protect the wound and patient from sepsis;
5. permit less painful dressing changes;
6. permit painless movement over joints;
7. facilitate debridement of wounds;
8. create good granulation tissue bed for autografting of deep wounds;
9. can be used to test for successful subsequent auto-graft;
10. decrease healing time of partial thickness burnsand donor sites and
11. improve quality of healing, inhibit excessive ®bro-blasts and decrease contraction [23].

Collagen-based dressings (Film/sheet/disc)

Collagen represents the chief structural protein accounting for approximately 30% of all vertebrate body protein. Currently there are a variety of interactive products that control the microenvironment on the wound surface and some bioactive products that stimulate some part of the healing cascade..At least 19 types of collagen have been reported.Types I, II and III collagen as well as types V and XI are built up of three chains and all are composed of the continuous triple-helical structure. Types I, II, III, and V are called as fibril forming collagens and have large sections of homologous sequences independent of species [14]. In type IV collagen (basement membrane), the regions with the triplehelical conformation are interrupted with large non-helical domains as well as with the short non-helical peptide interruption. Fibril associated collagens (Type IX, XI, XII and XIV) have small chains, which contain some non-helical domains.Type VI is microfibrilla collagen and type VII is anchoring fibril collagens [24].

The main application of collagen films is as barrier membrane. Films with the thickness of 0.01–0.5 mm and made of biodegradable materials, such as prepared from telopeptide-free reconstituted collagen, demonstrated a slow release profile of incorporated drugs [25] Collagen film/sheet/disc has been used for the treatment of tissue infection, such as infected corneal tissue or liver cancer. Soluble ophthalmic insert in the form of a film was introduced as a drug delivery system for the treatment of infected corneal tissue using a high dose of antibiotic agents, such as gentamicin [26] and tetracycline [27]. The collagen shield was originally designed for bandage contact lenses, which are gradually dissolved in cornea [28]. The idea of using a shield or a hydrogel lens as a delivery device has led to the development of various drug delivery systems for ophthalmic applications. One of the merits of the collagen-based drug delivery systems is the ease with which the formulation can be applied to the ocular surface and its potential for self administration [29].

Conclusion

The selection of wound dressing for treatment of wounds destined to heal by second intention or be treated by delayed closure can be important to the outcome. Different dressings have been shown to promote healing during different phases of the wound healing process. Generally speaking clean acute wounds are best dressed with an occlusive dressing until a healthy bed of granulation tissue develops. During the transition from the debridement to granulation tissue phase alginate dressings are recommended. Once granulation develops a semiocclusive dressing is recommended. Heavily contaminated or infected wounds are best treated with adherent dressings or particulate dextranomers or antimicrobial dressings until a healthy bed of granulation tissue develops, at this time a semiocclusive dressing is selected for the repair phase. Although the reports on biologic

bioactive dressings are limited and in some cases conflicting, they represent an important category of dressings that will undoubtedly realize more use in the future.

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