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A New Panorama of Wound Healing: A Review on Advances in Wound Healing Formulations

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ABSTRACT

From a divine creation to a massive complex system, this human body has slowly and steadily becomes less mysterious to us. With the up gradation, sophistication, and modernization of civilisation and technology and continuously changing teachings, and methodology, massively changed the care of both acute and chronic wounds. This article provides an overview of some of the methods employed and some are being used by physicians to enhance the wound healing process. The plurality of wound from Necrotic to malodorous have resulted in a wide range of wound dressings. If we try to define ideal dressing than it should achieve rapid healing at reasonable cost with minimal inconvenience better compatibility and feasibility to the patient. An attempt is made to write a review of the advances wound management dressings, emerging technologies for achieving improved wound healing, novel polymers used for the delivery of drugs to acute, chronic and other types of wound and It also reviews many of the dressings include adherent, non adherent, film dressing ,polysaccharides used in dressing, chitosan, alginates, hydrogel ,Foam dressing .Silicon dressing, deodorize, collagen and Larvae therapy. This review also concerns the requirement for formulations towards achieving optimum physical properties and desired characteristics for an active wound healing dosage form briefly.

Keywords: Hydrogel, Foam dressing , Chitosan, Silicon dressing.

1. INTRODUCTION

Wound may be defined as a disruption in the normal continuity of a body structure. [1] In recent years, accumulating knowledge regarding wound-healing process has led to the development of numerous therapies. World demand for wound management products will increase 5.3 percent annually to $39.3 billion in 2016, serving a $9.3 trillion worldwide health care industry. An expanding volume of surgical procedures coupled with a rising incidence of treated injuries and external skin conditions will underlie gains. Growth will also benefit from new product introductions, especially negative pressure therapy systems, skin replacements, tissue sealants, and wound healing agents.[2] In recent years, storing knowledge regarding wound healing processes has led to the development of numerous therapies. An abundant asset of novel, sophisticate topical preparations, dressing materials, and advanced methods of debridement are now at the hands of physicians and medical personnel, but still in many conditions dilemma are always there, even a specialist in the field of wound healing, such as dermatologists or plastic surgeons, may found themselves helpless to choose the most appropriate treatment.[3]

Wound - A system was developed in 1987 in the USA by The National Pressure Ulcer Advisory Panel, which is world widely accepted and majorly used to classify different kinds of wounds are as follows:

Stage I: Blanchable erythema (abnormal redness of the skin) of intact skin.
Stage II: Partial-thickness skin loss involving the epidermis and dermis, presenting clinically as an abrasion.

Stage III: Full-thickness skin loss, including the subcutaneous layer with extension down to (but not through) the underlying fascia.
Stage IV: Full-thickness skin loss with involvement of muscle, bone, or other deep structures such as tendons or joint capsules.[4]

Further clinical types of wounds or cutaneous ulcers were again classified as per the appearance especially color are as follows are:

1. Clean 'red' wounds
2. Secreting 'yellow' wounds
3. Dry 'black' wounds

Above classification was again expanded and described an additional type of ulcer, referred to as a 'sloughy' ulcer.
Process of wound healing –The complex process of wound healing is divided in to two distinct processes
i Regeneration when healing takes place by proliferation of parenchymal cells and usually results in complete restoration of the original tissues.
ii Repair start with the proliferation of connective tissue elements results in fibrosis and scarring .This distinct process is further divided in three phases
Phase 1. Inflammation phase (also called 'lag phase')
Phase 2.Tissue formation phase ('proliferative phase')
Phase 3.Tissue remodeling phase.[5]

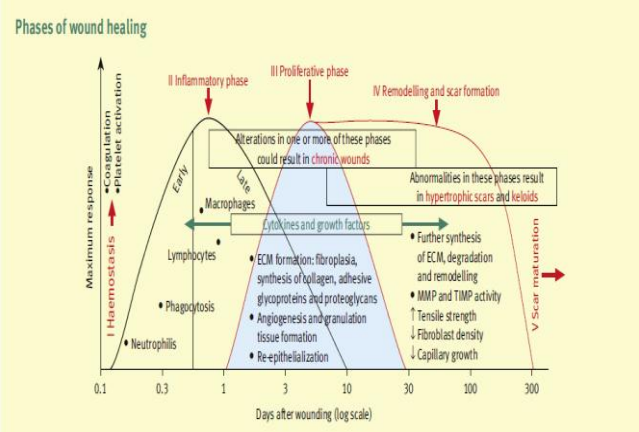

Figure- 1 Different Phases of wound healing [6]

2. WOUND DRESSING

Synthetic wound dressing originally of two types: Gauze based dressing and Paste bandages dressing. In the mid-1980s the first modern wound dressing was introduced which hold vital characteristics of an ideal wound dressing, which are as follows

1. Maintain a moist environment at the wound dressing interface.
2. Absorb excess exudates without leakage to the surface of the dressing.
3. Provide thermal insulation and mechanical protection.
4. Provide bacterial and fungal protection.
5. Allow gaseous and fluid exchange.
6. Absorb foul odor generated due to decay of the tissue and fluid.
7. Provide debridement action.
8. Be non toxic non allergenic, non sensitizing and sterile.

Further sophistication was done in the formulation of wound healing which shown remarkably new features in these formulation and reclassify the formulations as either adherent or nonadherent, absorbent or nonabsorbent.

Adherent dressings are normally 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.

Gauze dressings are generally highly absorbent and are still used for heavily contaminated exudative wounds. Non adherent dressings possess variable absorbency and are further divided into semi-occlusive, occlusive, and biologic types.

Occlusive dressings are made up of nonporous materials that have a low moisture vapor transmission.[7]

Semiocclusive dressings has moisture and vapor permeability. Synthetic, occlusive and semiocclusive materials create a moist wound healing environment and are considered interactive dressings under most circumstances.

Biological dressings can either be unprocessed natural or processed to form an extracellular matrix or a plasma rich platelet gel. The biologic dressings are considered bioactive contributing not only a matrix for repair but also growth factors and cytokines to enhance the healing process and they actually added additional desirable features that is enhancement of healing process in the wound healing formulations . [8]

The functionality of traditional and advanced wound dressings [9] and summary of available advanced wound dressings according to their origin, functions and applications are mentioned [10] (Table No. 1) (Table No. 2).

2.1 Adherent Dressing

2.1.1 Film Dressings (for wounds with no exudates or less exudates)

These dressings consisting of a thin, poly-urethane membrane coated with a layer of acrylic adhesive .They are water proof gas /vapour permeable , flexible, protect from shear, friction, chemicals , microbes and transparent.

They are particularly useful in superficial, clean wounds and in the prevention of breakdown and pre-ulcers in pressure wounds. It is also used as a post operative dressing over sutures and to reduce sub-tissue tension over a closed sutured wound after removal of the sutures or clips. Film dressings should not be used for infected wounds (Table No.3).

Table No. 1: Properties of Traditional and Advanced dressing

Traditional Dressing	Advanced dressing
Exudate absorption and drying of the wound	Keep a moist environment
Haemostatis	Remove exudates and necrotic tissue
Antiseptics	Keep temperature constant
Protection from infection	Oxygen permeable
Wound covering	Protection from exogenous infection
	Easy to handle
	Non traumatic at the dressing change

2.1.2 Bio film

Biofilm formation has been identified in many recent publications as a possible explanation for chronicity in wounds .A number of cases with diverse background pathologies, all resistant to traditional treatment and suspected of being complicated by biofilm presence, were selected for targeted therapy with an anti-biofilm agent.

Bacteria, as we traditionally know them, begin as the single seeds of a planktonic bacterium. They express proteins and structures for motility (flagella) and attachment (fimbriae). Their aim to seed themselves and disperse to different areas, thus exposing widespread areas to their presence and toxicity. In this form, they are susceptible to antibiotics, some antiseptics and the immune system. In acute wounds, bacteria are usually rapidly destroyed or inactivated by neutrophils, antibodies and common wound bed preparations. Bacteria are usually easily identified and cultured. In the chronic wound, however, the bacterium often takes on a different form. Small numbers of these single planktonic bacteria adhere to the surface of the wound by attaching to the exposed extracellular matrix, multiply and develop, over time, into microcolonies.

These colonies then aggregate into larger groups known as “biofilms”. The biofilm bacteria are encased in a self-manufactured extracellular polymeric substance or matrix. Within 10 hours each single-cell bacterium will have differentiated into a complex community, with defenses and resistance to antibiotics.[11]

The presence of biofilm renders the wound much more resistant to traditional therapy. Ideally, agents used for the treatment of biofilm should be able to disrupt its structure. Traditional antibiotics are better at destroying individual bacteria than colonies biofilm. Flavonix® is a gel that consists of a combination of agents that target exuberant inflammation and bacterial biofilm formation. [12-17]

2.2 Non adherent dressing

Some products, have a so-called 'non-adherent' or 'low-adherent' because pad located in the centre of an adhesive retention layer and are therefore described as non-adherent, low-adherent. Depending upon the nature of the wound contact layer and the strength of the adhesive bond formed between the dressing and the skin, removal of such dressings seldom damage the fragile, newly-formed epithelium leading to extended healing times and/or cause further trauma to the surrounding skin.

3. POLYSACCHARIDES FIBERS IN THE WOUND MANAGEMENT

From Ancient Era fibers have been unseparable part of Wound Management. These fibers afford a bioactive matrix for design of more biocompatible and intelligent materials owing to their remarkable molecular structure. Oligosaccharides and polysaccharides are biopolymers commonly found in living organisms, and are known to reveal the physiological functions by forming a specific conformation. Many Intensified efforts have been imparted in recent years in identifying the biological functions of polysaccharides related to their potential biomedical applications.

Table No 3: Commercial alginate based wound dressings

1	AlgiDERM	Bard
2	AlgiSite	Smith & Nephew, Inc
3	Tegagen HG, Tegagen HI	3M Health Care
4	SeaSorb	Coloplast Sween Corp
5	SORBSAN	Dow Hickam
6	Restore	Hollister
7	PolyMem	Ferris Mfg
8	Maxorb	Medline
9	KALTOSTAT	ConvaTec
10	KALGINATE	DeRoyal
11	Hyperion Advanced Alginate Dressing	Hyperion Medical, Inc.
12	Gentell	Gentell
13	Dermacea Sherwood	Davis & Geck
14	CURASORB, CURASORB Zinc	Kendall
15	CarraSorb H	Carrington
16	FyBron B	Braun
17	Algosteril	Johnson & Johnson

3.1 Classification of polysaccharides

Polysaccharides can be classified based on their molecular structure, like polysaccharides with

i. Rod-shape molecules like alginates, xanthans and chitosans
ii. Linear random coil type structures like dextrans and pullulans
iii. Branched structures like glycogen and amylopectin
iv. Polyanions such as alginates, pectins, carrageenans, xanthans and hyaluronic acid
v. Polycations such as dextran derivatives and chitosans
vi. Neutral structures such as guar, pullulan and dextran.

Table No. 4: Non-Absorbing dressings

Brand	Manufacturer	Type
Opsite™	Smith & Nephew	Plain film, Island Film Flexigrid Flexi Fix {continuous rolls} IV 3000 {high MVTR*} Post-op {island dressing}
Tegaderm™	3M	Plain film HP* {high MVTR} with absorbent pad island dressing
Biofilm™	Johnson & Johnson	Plain film
Polyskin™ II Aqua Protect® Hydrofilm®	Tyco Beiersdorf Hartmann	Plain film MR* {high MVTR} Plain film ,Island Film ,Plain film

*MVTR = Moisture Vapour Transmission Rate ie. the level of passage of water vapour or exudate
through the surface of the dressing.
*HP = Holding Power
*MR = Moisture Responsive

3.2 Alginate fibers

Alginate is the main constituent of brown algae and is found in the cell wall and intercellular regions. Apart from that it is a natural polysaccharide extracted from brown seaweeds. Alginate fibers can be made by extruding the water-soluble sodium alginate solution into an aqueous solution of calcium chloride in a bath, by using a simple wet spinning process. The resultant calcium alginate fibers have been known for many years for their non-inflammability, due to the high concentration of metal ions in the fibers.[19-21]

Alginate fibers are considered as non-toxic, non-carcinogenic, non-allergenic, highly absorbent, haemostatic, of reasonable strength, biocompatible, capable of being sterilized, and versatile to incorporate medicaments and using cheap nonwoven technology to process it.

They have been increasingly used for the treatment of diabetic foot ulcer. They formed a hard occlusive matt over the ulcer and thus prevent continuous drainage. A collagen – alginate – fiber wound dressing is also an effective dressing for the management of foot ulcer. Nonwoven alginate fabrics have gained attention as disposable textiles especially in wound dressings. Shorter production cycles, high flexibility and versatility and low production cost are some of the claimed advantages. There are various types of nonwoven wound dressings comprising alginates.

The novel antimicrobial wound dressings could also be made by blending calcium alginate fibers with the antimicrobial agents like silver-containing Static fibers. In this sort of system, the calcium alginate fibers provide the high absorbency and gelling ability, while the silver-containing fibers provide the sustained release of silver ions(Table No .3).

Modifications of alginate fibers can be performed on absorption, retention properties, nonimmunogenic, bioerodible implantation composition and incorporation of medicants to assist the natural haemostatic property of the fiber. Absorbency of alginate fiber by 120 times its own weight by blending of carboxymethyl cellulose with alginate they aimed to improve the swelling and reducing the brittleness of alginate fibers has been attempted .[22]

3.3 Chitin and chitosan fibers

Chitin and chitosan are known biodegradable natural obtained polysaccharides, polymers ,which are extracted from various animals and plants. Chitin is one of the most abundant organic materials easily obtained from natural sources, e.g., the shells of crustaceans (lobsters, shrimps, crabs, and etc.) or the broth from the industrial fungal processes.

chitosan is also known to have wound-healing acceleration properties and a number of studies have shown that chitosan fibers have unique properties as a suture and wound dressing material.

3.4 Biological properties of chitin and chitosan

- Bio compatible, natural polymer, Biodegradable to normal body constituents, safe and non toxic.
- Binds to mammalian and microbial cells aggressively
- Regenerative effect on connective tissue
- Accelerates the formation of osteoblasts, responsible for bone formation

Table No. 5: List of Advanced dressing available in the market with price

Dressing	Type	Company	Material	Price #/cm^2
Bioclusive[@]	Film	Johnson & Johnson	Polyurethane	0.75
Mitraflex[@]	Film	BritCair	Polyurethane	0.75
Omiderm[@]	Film	Litro Medical	Polyurethane	0.75
Opsite[@]	Film	Smith and Nephew	Polyurethane	0.70
Spyrosorb[@]	Film	Polymedica	Polyurethane	1.40
Tegaderm[@]	Foam	3M Health Care	Polyurethane	0.60
Lyoform[@]	Foam	Selon	Polyurethane	0.75
Allevyn[@]	Foam	Smith & Nephew	Polyurethane	0.95
Tielle[@]	Deodorizing	Johnson & Johnson	Polyurethane	1.20
Carbonet[@]	Deodorizing	Smith and Nephew	Activated Charcoal Cloth	1.50
Granuflex[@]	Bioactive	Conva Tech	Hydrocolloid	1.80
Duoderm[@]	Bioactive	Conva Tech	Hydrocolloid	0.70
Granugel[@]	Bioactive	Conva Tech	Hydrogel	8.30
Intrasite gel[@]	Bioactive	Smith & Nephew	Hydrogel	12.00
Nu-gel[@]	Bioactive	Johnson & Johnson	Hydrogel	8.20
Sterigel[@]	Bioactive	Selon	Alginate	8.30
Algisite[@]	Bioactive	Smith and Nephew	Alginate	2.10
Kaltostat[@]	Bioactive	Conva Tech	Alginate	2.05
Tegagel[@]	Bioactive	3M Health Care	Alginate	2.05
Mepore[@]	Traditional	Molnlycke	Non woven polyster fabric	2.10
Experimental	Chitosan	SCTIMST	Chitosan/Alginate	0.15

- Hemostatic
- Bacteriostatic
- Fungistatic
- Spermicidal
- Antitumor
- Anticholesteremic
- Central nervous system depressant
- Immunoadjuvant

The origins for chitin being propounded as a candidate for wound healing. Based on their study of the use of cartilage in accelerating wound healing, they deduced that the active component was Nacetyl- glucosamine. Chitin obtained from shrimp and fungal sources could be applied as topical powders on wounds. Eventually, results confirmed chitin's accelerating effect in wound healing. The authors proposed that the chitin powders released N-acetyl-glucosamine as a consequence of the breakdown of chitin by the enzyme lysozyme, abundantly present in fresh and healing wounds.

In another study, a chlorhexidine containing chitosan-based wound dressing was shown to have antibacterial efficacy towards the primary wound bed bacteria, *Pseudomonas aeruginosa* and *Staphyloccocus aureus.*

Chitosan can be easily dissolved in aqueous solutions of almost all the organic and inorganic acids because of the primary amine group on the C-2 position of the glucose residue. Chitosan fibers can be made by first dissolving it in an aqueous acidic solution and then extruding the solution through fine holes into a coagulation bath of a dilute alkali solution. Chitosan precipitates out in the form of a filament which can be washed, stretched and dried to form fibers for the production of wound dressings.[23]

Researchers also reported that The electrospinning technology opens enormous possibilities for the preparation of chitin and Chitosan mats for antimicrobial and wound healing applications. Chitosan nano-fibrous obtained by electrospun mats are promising for wound healing applications as they could demonstrate the antibacterial activity of the photocrosslinked electrospun mats against *Staphylococcus aureus* and *Escherichia coli* .[24]

A naturally occurring antibacterial agent was derived from chitosan obtained from crab cell. It was effective against both pathogenic gram positive and gram negative bacteria and also prevented from forming offensive odors.

Researchers are focusing on the modification of the structure of chitin polysaccharides with a view of enhancing their mechanical and chemical property. Chitin with enhanced tensile strength and modulus was produced from chitin/chitosan acetate/formate polymer which would open new dimension for wound healing formulations.

3.5 HYDROGEL

On a molecular level, hydrogels are three-dimensional networks of hydrophilic polymers. Depending on the type of hydrogel, they contain varying percentages of water, but do not altogether dissolve in water. Despite their high water content, hydrogels are capable of additionally binding great volumes of liquid because of the presence of hydrophilic residues. Hydrogels swell extensively without changing their gelatinous structure and are available for use as amorphous (without shape) gels and in various types of application systems, e.g. flat sheet hydrogels and non-woven dressings impregnated with amorphous hydrogel solution.[25]

Table No. 6: Different non-adhesive films

Dressing	Manufacturer	Codes
Activheal Foam Heel	ACT	H, WCL
Activheal Non-adhesive foam	ACT	H, WCL Allevyn
Ag Non-adhesive	SN	H, WCL, Ag
Allevyn Heel	SN	H, WCL
Allevyn Non-adhesive	SN	H, WCL, FEN
AMD Antimicrobial Dressing	COV	H
Askina Foam	BB,	H Heel
Biatain IBU	COL	H
Comfifoam	SYN	H
Copa Plus	COV	H
Medifoam	BIO	H, FEN
Optifoam Ag Non-adhesive	MED	H, Ag
Optifoam Non-adhesive	MED	H, FEN
Polymem	FE	L, SA
Polymem Max	FE	H, SA
Polymem Silver	FE	L, SA, Ag
Polymem tube	FE	L, SA
Sof-Foam	JJ	H
Suprasorb P	LR	H
Tegaderm Foam	3M	H

H' Heavily exuding wounds, 'L' Lightly exudi ng wounds, 'FEN' Fenestrated dressing, 'Ag' Silver,' SA' Superabsorbent, 'WCL' Low-adherent or silicone wound contact layer

These products consist of hydrophilic homopolymers or copolymers which interact with aqueous solutions, absorbing and retaining significant volumes of fluid. Flat sheet hydrogel dressings have a stable crosslinked macrostructure and therefore retain their physical form as they absorb fluid. The selected dressing in this case study was a sheet hydrogel. [26]

Hydrogels, in the form of amorphous gel, have been successfully used for aiding debridement for longer than a decade, their primary role being particularly rehydration of dry necrotic wounds. Hydrogel dressings can be used on necrotic, sloughy, granulating, and epithelializing wounds and can be used in infected wounds if the patient is receiving systemic antibiotics and the dressing is changed daily [27].

Hydrogels are therefore of value in a wide spectrum of wounds. Most hydrogels have a high water content of approximately 70% and it is this factor that successfully promotes rehydration. Hydrogels also have the ability to absorb some fluids from low exuding wounds, However, if used in sloughy and highly exuding wounds, hydrogels can begin to donate fluid to the wound and this can increase the fluid levels in the secondary dressings and may escalate potential for this fluid to macerate the surrounding tissues. Slough is partly rehydrated necrotic tissue and also requires a moist environment if complete debridement is to be achieved.[28]

4. FOAM DRESSING

Various forms of foam has a long history in wound management. They are mainly made from polyurethane, appear to satisfy most of the requirements of the 'ideal dressing' and as a result have become the treatment of choice for many types of wounds. Unlike hydrocolloid sheets , foam dressings tend not to facilitate autolytic debridement of very dry wounds, and are therefore most commonly indicated for exuding lesions.

4.1 Classification of foam dressing

Cavity dressings Silastic Foam, consisted of two components, a viscous medical-grade poly(dimethylsiloxane) base and a stannous octoate catalyst which were mixed together immediately prior to use. The resultant chemical reaction released hydrogen which caused the viscous mixture to expand to approximately four times its original volume before setting to form soft, resilient, open-cell foam.

For the application the liquid catalyzed base was inserted into the colon as an enema where it expanded and set, taking up the shape and surface characteristics of the gut wall. This somewhat unusual procedure was superseded when improved radiological techniques and more sophisticated instruments were developed.

When used as a dressing, the two components were mixed as before, and then introduced directly into the lesion to form a 'stent' that precisely adopted the contours of the wound. The stent usually remained in position in a deep wound without the need for bandages or secondary dressings, but as healing progressed and the wound became shallower, the use of surgical tape or some other form of retention was sometimes required. [29]

5. HYDROCOLLOID WOUND DRESSING

Hydrocolloid provides an ideal environment for the formation of granulation tissue, particularly for the activity of fibroblasts, accelerating the healing process. It also facilitates debridement by promoting autolysis. High absorption capacity rapidly and reliably binds away excessive exudate, extending dressing change intervals.

Bevel edge provides optimum fit and reduces risk of detachment. A stable, hydrocolloid matrix within the dressing minimizes gel residues and skin irritation. Patient comfort is promoted by using material components that are highly flexible. The slightly transparent nature of material enables effective positioning on wound. In addition to the standard Hydrocolloid product, two other formats are provided:

Hydrocolloid Basic which contains a PU foam backing to provide extra cushioning and
Hydrocolloid Thin which has a lower absorption capacity for use during the epithelialisation phase.[30]

6. SILICON DRESSINGS

Soft silicone dressings have been available for over 10 years and were developed to minimize problems of pain and trauma at the time of change in dressing , to protect the peri-wound skin and promote comfort during wear.

Silicones are inert, synthetic compounds, which can vary in forms from oil, to rubbers and hard resins. They are made up of long chain polymers that include repeating chains of silicon together with carbon, hydrogen, oxygen and sometimes other elements. Soft silicones are a particular family of solid silicones, which are soft and tacky. These properties enable them to conform and adhere well to dry surfaces. Such silicones have low toxicity, making adverse reactions rare, and they cannot be absorbed into the body ,This make them ideal for use in wound dressings. [31]

However, not all soft silicone dressings are the same and clinicians need to understand how different products vary when selecting the most appropriate dressing for the patient and the wound. It has been shown that when removed from the skin, soft silicone dressings do not cause trauma to the wound or periwound skin .They have been described as 'atraumatic' for this reason.[32-36]

Different benefits of using soft silicone dressings are as follows -

1. Low trauma with minimal adhesion to the wound bed or surrounding skin — increasing patient comfort and minimizing pain at dressing changes.
2. Flexible and conform well to body contours
3. Safe to use (unlikely to cause sensitivity reactions, do not produce any systemic effects)
4. It may also help to prevent the development of hypertrophic scars or keloids after surgery
5. Cost-effective — minimizes need for analgesia at dressing changes and may offer longer wear time.

Dressings that incorporate soft silicones have different target functions suited to particular clinical needs. A wound contact layer to be used with a secondary dressing to increase comfort and minimize disruption to the wound bed, absorbent dressings for moderate to highly exuding wounds and as a first-line treatment for wounds at risk of hypertrophic scarring or keloids. [37]

6.1 Silicone gel sheets

Silicone gel sheets are thicker and do not require a secondary dressing and should only be used on healed wounds to reduce or prevent hypertrophic and keloid scarring.[38]

7. COLLAGEN DRESSINGS

There are a number of different collagen dressings available, which employ a variety of carriers/combining agents such as gels, pastes, polymers, oxidized regenerated , and ethylene di-amine tetra-acetic acid .The collagen within these products tends to be derived from bovine, porcine, equine, or avian sources, which is purified in order to render it nonantigenic. The collagen in a given collagen dressing can vary in concentration and type. Certain collagen dressings are comprised of Type I (native) collagen; whereas, other collagen dressings contain denatured collagen as well. A given collagen dressing may contain ingredients, such as alginates and cellulose derivatives that can enhance absorbency, flexibility, and comfort, and help maintain a moist wound environment. Collagen dressings have a variety of pore sizes and surface areas, as well. All of these attributes are meant to enhance the wound management aspects of the dressings. Many collagen dressings contain an antimicrobial agent to control pathogens within the wound. Collagen dressings typically require a secondary dressing mode of action . Research has shown that some collagen-based dressings produce a significant increase in the fibroblast production. [39-43] The mode of action of several collagen dressings includes the inhibition or deactivation excess matrix metalloproteinase. As mentioned, excess matrix metalloproteinase are a key contributor to wound chronicity.

7.1 Pore Size and Surface Area

Pore size of collagen dressings is important to allow cells to enter the dressing and concentrate therein. In addition, surface area plays a role in managing exudate. Typically the larger the surface area, the more exudate is absorbed. Previously, collagens were thought to function only as structural support; however, collagen and collagen-derived fragments control many cellular functions, including cell shape and differentiation, migration, and synthesis of a number of proteins. Collagen also plays a critical role in all phases of wound healing (hemostasis, inflammation, proliferation, and remodeling)

8. DEODORISING DRESSINGS (EG CARBOFLEX)

Most deodorising dressings are made up of activated charcoal. There are reasons that wounds become malodorous and a thorough wound assessment should be undertaken to determine the cause of the odour.

8.1 Guidelines for use

1. Can be used in conjunction with other dressings
2. Can be combined with metronidazole gel for wounds colonised with anaerobic bacteria, however this should be for a short period only
3. Can be used on malignant wounds
4. Can be used on infected wounds; however the patient requires systemic antibiotic therapy
5. Daily dressing change.
6. Deodorising dressings should be used as a primary dressing. However they may stick to the wound bed, therefore the use of a non-adherant dressing is advised.

9. LARVAE THERAPY

Larvae are sterile maggots of the green bottle fly *Lucillia sericata* and have been found useful in cleansing and deodorising wounds that are infected or have devitalised tissue. The Larvae produce powerful proteolytic enzymes that breakdown sloughy or necrotic wound tissue, which is ingested as a source of nutrient.

9.1 Guidelines for use

1. Supplied in sterile containers or sterile nets, (biobags) which contain approximately 100 maggots
2. Suitable for a variety of wounds, pressure ulcers, leg ulcers, and diabetic foot ulcers
3. Can be used to prepare a wound for grafting
4. Although the maggots remain on the wound for a maximum of 5 days .
5. A hydrocolloid should be prescribed, as this will protect the surrounding skin. If using bio bag then a cream eg Sudocrem is used to protect the skin
6. Maggots are removed by irrigation, removing any remaining maggots with forceps
7. Any hydrogel used prior to larvae therapy must be completely removed from the wound as it kills the maggots by suffocation
8. Should only be used by practitioners who have received training in the use of maggots
9. Caution should be used if wounds have a tendency to bleed
10. Caution should be used for patients currently on anticoagulants. eg Warfarin
11. Caution should be used if wounds have a sinus or fistula
12. Larve should never be used on wounds that lie in close proximity to large blood vessels
13. Increased levels of pain have been reported when used on ischaemic feet.[44]

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Table No.2: Type, Function and Application of Advanced Wound dressings

Type	Example	Function	Form of Application
Film	Bioclusive C-View OpSite Plus Tegaderm	Vapour-permeable adhesive films, thin, very flexible, easy to mold around difficult shapes. They cool the surface of the wound. Excessive exudate may accumulate.	Suitable for shallow wounds,. Used to prevent pressure ulcers and retention dressing.
Hydrogel	Agaflo GrauGel Intrsite Gel Nu-Gek Sterigel	Hydrophilic polymers, partially crosslinked to form 3D network. Can absorb up to 100% if their weight. Promote moist healing, non-adherent, by cooling of the wounds surface they can reduce pain. Amorphous hydrogels are particularly useful for treating cavity wounds.	Most require covering with a secondary dressing, suitable for dry "sloughy"wounds and lightly exuding wounds. They are not good for infected or heavily exuding wounds. They are also good for drug delivery such a placental growth factors and antibiotics.
Hydrocolloid	Aquacel Comfeel Granuflex R. Ultec Pro	More complicated than hydrogels, contain constituets such as pectin methylcellulose &gelatin promote formation of granulation tissue and provide pain relief. Suitable for treatments of acute and chronic wounds, for desloughung; light to heavily exuding wounds.	Not suitable for infected wounds, usually require no secondary dressing, hence patients can bath & shower.
Alginate Dressing	Algisite M Comfeel Plus Kaltostat SeaSorb	Natural polysaccharides extracted from brown seaweed. At wound dressing surface sodium calcium exchange takes place between the dressing and the exudates respectively hence swelling and formation of gel.	Suitable for use of medium to heavily exuding wounds and cavity. They are more used on infected wounds. Most alginates require secondary dressing.
Foam	Avance Cavi-Care Flexipre Tielle	Polyurethane based, with or without adhesive borders, main applications are to absorb large volumes of exudates reducing the need for dressing changes.	Suitable for use on light to medium exuding wounds.
Silicon Dressing	Cica-Care Mepiform N-A Ultra	Consists of silicone gel, used to reduce hypertrophic and keloid scarring, cosmetically acceptable scars.	Gel sheet can be sterilized and are reusable.
Collagen	Oasis Opraskin Promogan SuabsorbC	Fibre-forming protein of mammalian connective tissue. It contributes to differ of wound healing by attracting granulocytes and fibreblasts into wounds and reduces wound contraction, etc.	Collagen is used as haemostat, an absorbable suture material, artificial skin, bone filling and wound dressing De-odoriser
Silicon Dressing	Cica-Care Mepiform N-A Ultra	Consists of silicone gel, used to reduce hypertrophic and keloid scarring, cosmetically acceptable scars.	Gel sheet can be sterilized and are reusable.
Non adherent dressing		Available non-impregnated or impregnated & prevent foreign matter to lodge in Wound bed. They used on skintears, donor site &skin grafts.	Most non-adherent dressings require a cover bandage or tape to hold them in a place.