CHAPTER I

GENERAL BACKGROUND

1. Introduction

One of the major carbohydrate found in nature is polysaccharide. Polysaccharide may be divided into two principle groups. The first group including substances such as glycogen, a major polysaccharide in animal tissues, is a storage polysaccharide. The second group of polysaccharides such as cellulose or pectin and starch, the structural and storage polysaccharide, respectively, are polysaccharides in plants (Mahler and Corde, 1966). Cellulose is the most abundant structural polysaccharide of plants. Starch is a storage polysaccharide, a nutritional reservoirs of plants. Pectin is a natural constituent of all terrestrial plants obtained from citrus peel and apple pomace (Polin, Nielsen, and Glahn, 1986). Polysaccharides are widely used in food, cosmetic, pharmaceutical products as thickeners, binders, stabilizers, film formers, gelling agents, suspending agents, and lubricants (Park, Cho, and Rhee, 2001).

There are reports about the utilization of plant waste as a source of valuable materials of commercial importance (Moure *et al.*, 2000; Singh, Murthy, and Jayaprakasha, 2002). Durian ,(*Durio zibethinus* L.), is one of the most favorite fruit in Thailand, the consequence of durian fruit-hulls waste become a big burden for treatment. In 1998, Pongsamart and Panmaung isolated the polysaccharide gel (PG) from fruit-hulls of durian. Varieties of durian polysaccharide gel applications are also studied. PG is a water soluble polysaccharide, composes of sugars such as glucose, rhamnose, fructose, arabinose and galacturonic acid (Pongsamart and Panmaung, 1998; Girddit *et al.*, 2001). The polysaccharide gel can be widely use in preparation of food and pharmaceutical products such as jelly, tablet, suspension and emulsion (Pongsamart *et al.*, 1989; Pongsamart, Dhumma-Upakorn, and Panmaung, 1989; Pongsamart and Panmaung *et al.*, 1998; Umprayn *et al.*, 1990). Toxicity test of PG has been studied, a high oral single dose (2 g/kg) did not induce severe toxicity in

male mice and rats (Pongsamart, Sukrong, and Tawatsin, 2001). Subchronic toxicity test indicated that PG has not induced toxic effect in male and female mice after longterm feeding at dose of 0.5 g/kg/d for 60-100 days (Pongsamart, Tawatsin, and Sukrong, 2002). Girddit *et al.* (2001) reported that PG can also be used as a film forming agent and it can be used to prepare a satisfactory film product as a dressing film. Lertchaiporn, Vayamhasuwan and Pongsamart (2002) has successfully formulated vitamin E gel and lotion using PG as a surfactant. The recent studied of PG by Lipipan, Nantawanit, and Pongsamart (2002) has discovered the medical valuable property of antibacterial activity against varieties of gram positive and gram negative bacteria such as *Staphylococcus aureus, Staphylococcus epidermitis, Micrococcus luteus, Bacillus subtilis, Lactobacillus pentosus, Esherichia coli,* and *Proteus vulgaris* (Nantawanit, 2001). Especially, *S. aureus* and *S. epidermidis,* are bacteria that normally found in skin and can cause wound infection and pus. According to the fascinating results of the film forming property and bactericidal activity of PG, it is expected to be a useful product for varieties of medical application such as dressing films, gel or cream for the treatment of wounds. According to review literature, there are some materials found to be useful in the treatment of wound such as :

Calcium alginate derived from seaweed has been reported that calcium alginate dressing have beneficial effects on wound healing by providing a moist wound environment and reduce cytotoxicity to fibroblast cells and showed rapid wound closure (Suzuki *et al.*, 1998).

Chitosan, a linear copolymer of linked β (1→4) glucosamine (2 – amino – 2 – deoxy – D - glucose) and N-acetyl – D - glucosamine (2-acetamido-2-deoxy-D-glucose), which is obtained by purifying deacetylated chitin which can be derived from chitin rich scrap shell. Chitosan have been used as a wound dressing and having a function in the acceleration of infiltration of PMN cells at the early stage of wound healing (Ueno *et al.*, 1999).

Fibroin is a silk protien and comprises the core of silk fiber. It was prepared to a silk film and was compared the function of silk film with two clinically used

dressing, hydrocolloid dressing and lyophilized porcine dermis, in the healing of murine full-thickness skin wounds. The results shown that silk film was faster healing and greater collagen regeneration than those other dressing (Sugihara *et al.*, 2000)

Honey, sugar and sugar paste were used to a dressing for treated wound, honey showed antimicrobial properties, and prevent hypergranulation and scarring on wound (Moore *et al.*, 2001; Topham, 2002).

All of those materials may affect at any phases in wound healing process: The process of wound healing consists of 3 overlapping phases: inflammatory phase is the first phase in infiltrating inflammatory cells (PMNs and macrophages) to clean the foreign agent and microbial in the wound. The second phase of wound healing is proliferative phase, the fibroblasts were migrated into wound and collagen was synthesized. The remodeling phase is the last phase, the wound was healed and repaired (Lawrence, 1998). Wound management is performed by initial cleansing, debridement and after antiseptic procedures have been completed, the next step the wound management was covered wound by dressing for stop bleeding and prevent wound infection (Foster, Rowedder and Reese, 1995). In the early 1962s, Winter determined that wound kept moist is healed better than those exposed to the air. These data led to a gradual evolution in the nature of professional wound care materials as manufacturers began to develop dressing from materials that keep wound moist and to promote wound healing such as alginate dressing, chitosan dressing, silk film dressing, and honey dressing.

The polysaccharide gel is a water-soluble polysaccharide, it has film forming property and can be used to prepare as a satisfactory film (Gerddit, 2002) and its antimicrobial property. Especially, against *S. aureus* and *S. epidermidis* (Nantawanit *et al.*, 2001) which is usually found in skin and can cause wound infection. The preliminary study of PG film on wound treatment has been demonstrated (Subhachalat *et al.*, 2002). They applied PG dressing film, which was prepared from PG isolated from fruit-hulls of durian, for treatment of full-thickness wound on pig skin in comparison with the treatment with povidone iodine and covered with commercial dressing such as fixomull or gauze. Their results demonstrated that PG dressing film showed rapid wound closure and slight tissue reaction compared to those of other traditional treatments. The fascinating results of this study are

encouraging to find a deep presumtive evidence to proof an effectiveness of PG dressing film in wound healing. Therefore, the aim of this study was to prepare and evaluate the dressing film of polysaccharide gel from fruit-hulls of durian on healing wound in pig skin *in vivo*.

The pig skin was used in this study, because it is the most resemblance to human skin. Like man, the pig has sparse cover of hair ; the epidermis has a well differentiated under-sculpture, the dermis has thick papillary body and rich population of elastic fibers, these are specious similarities. However, there are many differences from the human skin such as (a) the pig's hair is coarser than that of human; (b) the man has mostly eccrine sweat glands over the body surface but the pig has only apocrine glands and (c) the pilo-sebaceous apparatuses of the man are richly vascularized, but those of pig are not (Montagna and Yun, 1963; Chvapil, Chvapil, and Owen, 1987).

2. Literature reviews

2.1 The Skin

2.1.1 Structures of The Skin (Marieb, 1981 ; Wynsberghe, Noback, and Carola, 1995)

The skin is the largest organ in the body, occupying almost 2 m^2 of surface area. Skin has three main parts: *the epidermis*, *dermis*, and *hypodermis*, as illustrated in Figure 1.

Epidermis

The epidermis is the outer layer of epithelial tissue and avascular, having no blood supply. It consists of five typical layers. There are, ***the stratum corneum*** is upper layer consists of flattened keratinized cells (keratin). The keratin is a protein with waterproofing properties, preventing water loss from the deep tissue. Keratinized cells are dead, and so they are constantly rubbing and flanking off and being replaced by the division of deeper cells. ***The stratum lucidum*** is beneath the stratum corneum, consists of the flat, translucent layers of dead cells that contain a protein called eleidin (a keratin precursor). The stratum lucidum appears only in the plams of the hands and sole of the feet, acting as a protective shield against the ultraviolet ray of the sun. ***The stratum granulosum***; below the stratum lucidum, is the area in which the cells begin to die due to their accumulation of eleidin and their increasing distance from the dermal blood supply. ***The stratum spinosum*** contains 8 to 10 layers of closely packed cells, joined together by spiny projections, hence prickle cell. These cell have limited capacity for mitosis, and ***the stratum basale*** is consists of a single layer of columnar or cuboidal cells. It undergoes continuous cell division to produce new cell to replace those being shed in the exposed superficial layer. It also contains melanocytes, cells that produce malanin (a pigment that helps protect from UV radiation).

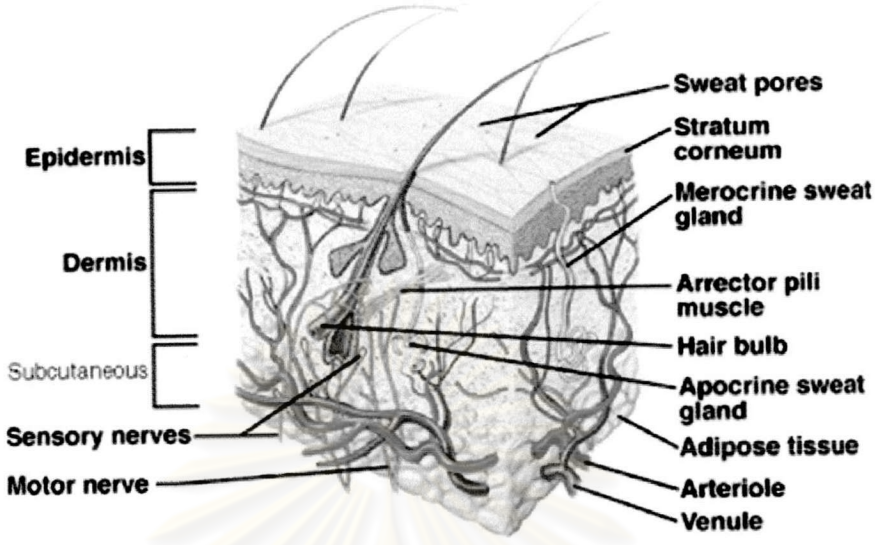

Figure 1. The structure of skin composed of 3 layers; epidermis, dermis and subcutaneous. The picture available from http://www.bmb.psu.edu/courses/bisci004a/tissues/skin.jpg, 2003)

Dermis

The dermis consists of two principle regions: the papillary and recticular layers. The papillary layer of the dermis consists of loose connective tissue with thin bundles of collagenous fibers. The reticular layer is made up of dense connective tissue with coarse collagenous fibers and fiber bundles that crisscross to from a strong and elastic network. The cells of the dermis are mostly fibroblasts, fat cells, and macrophages. Blood vessels, lymphatic vessels, nerve endings, hair follicles, and glands are also present.

Hypodermis

The hypodermis (subcutaneous) is beneath the dermis; composed of loose, fibrous, connective tissue. The hypodermis is generally much thicker than the dermis and is richly supplied with lympathic, blood vessels and nerves. Also within the hypodermis are the coiled ducts or sudoriferous (sweat) glands and the base of hair follicles. The boundary between the epidermis and dermis is distinct; that between the dermis and the hypodermis is not.

2.1.2 Function of Skin

Wynsberghe *et al.* (1995) described that the function of the skin are as followings; (1) *protection*; the skin acts as a stretchable protective shield that prevents harmful microorganisms and foreign materials from entering the body; (2) *temperature regulation* by excreted through the pores of sweat glands; (3) *excretion* through perspiration, small amounts of waste materials such as urea are excreted through the skin.; (4) *synthesis vitamin D*; and (5) *sensory reception*; the skin containing sensory receptors that respond to heat, cold, touch, pressing and pain.

2.2 Types of wound

Wounds can be broadly categorized as having either an acute or chronic etiology. ***Acute wounds*** are caused by external damage to intact skin and include surgical wounds, bites, burns, minor cuts and abrasion and more severs traumatic wounds such as lacerations and those caused by crush or gunshot injuries, acute wounds are expected to heal within a predictable time frame. ***Chronic wounds*** are most frequently caused by endogenous mechanism associated with a predisposing condition that ultimately compromises the integrity of dermal and epidermal tissue. Pathophysiological abnormalities that may predispose to the formation of chronic wounds such as leg ulcers and pressure sore. Chronic wounds types, heal slowly and an unpredictable manner (Bowler, Duerden, and Armstrong, 2001).

2.3 **Wound Healing** (Regan and Barbul, 2000)

The process of wound healing can divide into 3 overlapping phases that merge into a continuous process as present in Figure 2.

2.3.1 Inflammatory Phase (Day 0-5)

Coagulation : After injury, causes hemorrhage from damaged vessels and lymphatics. Vasoconstriction occurs almost immediately as a result of release of catecholamines. Various other vasoactive compounds, such as bradykinin, serotonin, and histamine, are released from tissue mast cell. They initiate the process of diapedesis, a passage of intravascular cells through vessel walls and into the extravascular space of the wound. Platelets derived from the hemorrhage or a hemostatic clot. Platelets release clotting factors to produce fibrin, which is hemostatic and which forms a mesh for the further migration of inflammatory cells and fibroblast. Platelets are also extremely important because they are the first cells to produce several essential cytokines, which modulate most of the subsequent wound healing events (Cohen *et al.*, 1999).

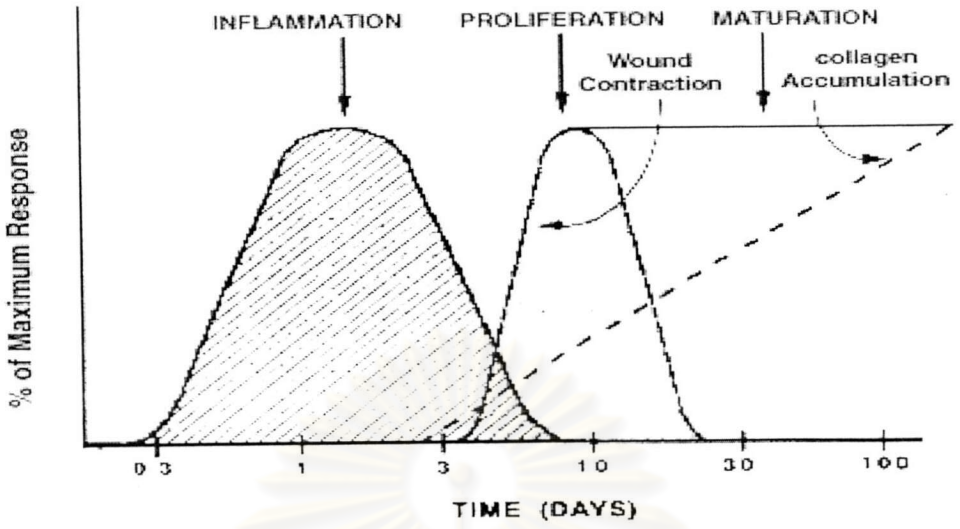

Figure 2. Three overlapping phases of wound repair: inflammation , proliferation and maturation (Regan and Barbul, 2000). Available from : http://www.tissuesealing.com /uk/surgical/overview/vol1_3-17.cfm.

Inflammation: Within 6 hrs, circulating immune cells appear in the wound. Polymorphonuclear leucocytes (PMNs) as neutrophils are the first blood leucocytes to enter the wound site. They initially appear in the wound shortly after injury and subsequently their numbers increase steadily, peaking at 24-48 hrs. The role of the neutrophils is to kill organisms and to facilitate breakdown of debris by extracellular release of their enzyme (Bertone, 1989). The next cell that appears in a wound is the macrophage (Greenhalgh, 1998). The role of macrophage just like neutrophils phagocytes and digest pathological organisms and tissue debris (Regan and Barbul, 2000). Macrophages regulate tissue repair through the release of several growth factors and cytokines that stimulate fibroblast proliferation, collagen production, and other healing process. Among these are TNF-α, PDGF, TGF-β, IL-1, and others, as presented in Table 1.

2.3.2 Proliferative Phase or Regenerative Phase (Day 3-14)

The proliferative phase is characterized by the formation of granulation tissue in the wound. *Granulation tissue* consists of a combination of cellular elements, including fibroblasts and inflammatory cells, along with new capilaries embedded in loose extra cellular matrix of collagen, fibronectin and hyaluronic acid. Fibroblasts first appear in significant numbers in the wound on the third day post-injury and achieve peak numbers around the seventh day. Fibroblast produces large quantities of collagen, which subsequently reorganized, by cross-linking, into regularly aligned bundles oriented along the lines of stress in the healing wound. The process of fibroblast proliferation and synthetic activity is known as *fibroplasia*.

Revascularization of the wound proceeds in parallel with fibroplasia. Capillary buds sprout from blood vessels adjacent to the wound and extend into the wound space. On the second day post-injury, endothelial cells from the side of the venule closest to the wound begin to migrate in response to angiogenic stimuli occurred *angiogenesis*.

Table 1. Cytokine that affect wound healing (modified from Cohen *et al.*, 1999 ; Lawrence, 1998)

Cytokine	Symbol	Source	Functions
Platelet-derived growth factor	PDGF	Platelets, macrophages, endothelial cells, keratinocytes, smooth muscle cells	Inflammatory cells (PMNs, macrophages) and fibroblasts migration, collagen synthesis
Transforming growth factor beta	TGF-β	Platelets, T lymphocytes, macrophages, endothelial cell, keratinocytes, fibroblasts	Inflammatory cells and fibroblasts migration, collagen synthesis
Epidermal growth factor	EFG	Platelets, macrophages, saliva, Urine, milk, plasma	Mitogenic keratinocytes and fibroblast; stimulates keratinocytes migration and granulation tissue formation
Transforming growth factor alpha	TGF-α	Macrophages ,T lymphocytes Keratinocyte and many tissues	Similar to EFG
Fibroblast growth factor 1 and 2 Family	FGF1, FGF2	Macrophages ,T lymphocytes, Mast cell, fibroblasts and many tissues	Mitogenic for fibroblasts, angiogenesis, epithelialization, and collagen synthesis
Keratinocyte growth factor	KGF	Fibroblasts	Stimulates keratinocytes migration, proliferation and differentiation
Insulin-like growth factor-1	IGF-1	Liver, macrophages, fibroblasts and other	Fibroblasts proliferation, epithelialization
Connective tissue growth factor	CTGF	Endothelial cells, fibroblasts	Chemotactic and mitogenic for various connective tissue cells
Vasular endothelial cell growth factor	VEGF	Keratinocytes	Mitogenic for endothelial cells
Tumor necrosis factor	TNF	Macrophages ,T lymphocytes, Mast cell	Activates macrophages, mitogenic for fibroblasts, angiogenesis
Interleukins	IL-1, etc.	Macrophages ,T lymphocytes, Mast cell and many tissues	Chemotactic for PMNs, and fibroblasts, regulates other cytokines
Interferons	INF-α	Lymphocytes and fibroblasts	Activates macrophages, inhibit fibroblasts proliferation and regulates other cytokines

Re-epithelialization of the wound begins within a couple of hours of the injury. Epithelial cells, arising from either the wound margins or residual dermal epithelial appendages within the wound bed, begin to migrate under the scab and over the underlying viable connective tissue.

Wound contraction begins within 1 to 2 weeks of injury, resulting from fibroblast movement and myofibroblast interaction. Fibronectin and other factors regulate the process.

2.3.3 Maturation Phase or Remodeling Phase (Day 7 to 1 year)

The final phase of tissue repair is the maturation or remodeling phase, which continue for up to 1 year or even longer. Collagen is still synthesized but collagenase production also increase to create a balance between collagen production and degradation (Greenhalgh, 1998). Wound has been closed by connective tissue and epithelialization. Vascularity decreases, fibroblasts shirk and collagen fibers alter red, granulation tissue to white and thickened wound (Sawyer, 2002).

Scar formation; the final product of the healing process is a scar formation. Scar tissue is a matrix of cells and fibers embedded in a ground substance (Forester, 1988). This relatively a vascular and acellular mass of collagen serves to restore tissue continuity, strength and function (Regan and Barbul, 2000), while abnormalities of the healing process may lead to abnormal scar formation as keloids and hypertrophic scars. Hypertropic scars enlarge in size or bulk, most common within loose skin and over convex surface, whereas keloids enlarge by cellular proliferation, can occur anywhere, but almost often in areas such as the upper back, shoulder, anterior chest, and upper arm (Foster *et al.*, 1995).

2.4 Principle of Moist Wound Healing

Since Winter reported in 1962 that wound is more healed faster and with better structure in healed tissue under moist wound environment by dressed with occlusive dressing material (polythene film) than those dry wound environment by left exposed to the air. In his experiment Winter described that when the wound kept moist under a polythene film, epidermis migrate and mitosis through the serous exudate on the wound surface above the fibrous tissue of the dermis. In contrast to the normal dry wound environment, epidermal migrates below the dehydrated fibrous tissue where there is sufficient moisture for the cells to live as illustrated in Figure 3. The concept of moist wound treatment supported by the results reported by Winter and Scales in 1963. They demonstrated that wound dressed with occlusive dressing showed doubles the rate of wound re-epithelization compared with wounds exposed to the air in pig skin. It is the same results reported by Hinman, Maibach, and Winter (1963), they demonstrated in human skin. Leipziger *et al.* (1985) reported that wound dressed with polymer dressing accelerated collagen synthesis than air expose wound in pig skin. The effects on dermal repair of moist condition and dry condition were compared by Dyson *et al.* (1988). From the results, the moist condition dressed by polyurethane dressing more rapid increase fibroblasts and endothelial cells, and more repair than that dry condition dressed (gauze dressing). These results correlated with the results of Vogt *et al.* (1995) and Ueno *et al.* (1999). From the reasons that wound rapid healed in moist condition, the wound dressing was developed from the materials that can retain moisture on wound and promote wound healing.

Besides, the wound dressing accelerate wound healing, also the other factors were affect wound healing as represented in Table 2.

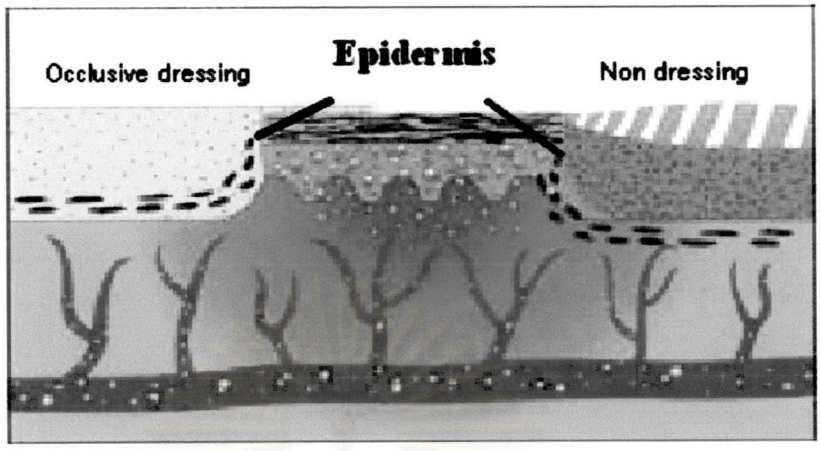

Figure 3. Schematic represented Winter's moist wound healing thesis. The wound surface moist under dressed with occlusive dressing showed migration of epithelial cells over granulation tissue. Incontrast, non dressing provides dry environment, epithelial cells migrate beneath wound surface which moist than those surface that lead prolong healing. The figure available from http:// www. biopol.co.kr/ensub/skin_1.gif.

Table 2. The factors that affect wound healing (modified from Cohen *et al.*, 1999)

Local factors	General factor
Blood supply	Age
Hematoma	Anemia
Infection (local)	Anti-inflammatory drugs
Mechanical stress	Hormones
Protection (e.g.,dressing)	Infection (system)
Surgical technique	Obesity
Suture material and technique	Temperature
Type of tissue	Trauma
	Uremia
	Malnutrition
	Vitamin deficiency
	Trace metal deficiency

2.5 Wound Dressing

No single dressing is appropriate for all wound types and all stage of healing. The ideal of wound dressing collected by Ladin (1998) and Biopol (2002) should be including properties such as

- Protect the wound
- Promote wound healing (Dyson *et al.*, 1988; Vogt *et al.*, 1995; Claus *et al.*, 1998)
- Prevent dehydration and desiccation and maintain a moist environment (Berardesca *et al.*, 1992 ; Field and Kerstein, 1994).
- Allows gas exchange
- Allows removal without trauma and reduce pain (Nemeth *et al.*, 1991; Field and Kerstein, 1994).
- Be non-toxic, non-allergenic and non-sensitizing.
- Act as a barrier to virus and bacteria (Field and Kerstein, 1994; Leaper, 1994; Lawrence, 1994)
- Not shed fiber into the wound
- Not adhere to the wound (Cochrane *et al.*, 1999)

And should be

- Absorbent
- Haemostatic
- Debriding
- Easy to use
- Inexpensive

2.6 Type of Wound Dressing

Hall (2001) classified the wound dressing into 2 types. ***The primary dressing*** is in direct contact with the wound surface and provides absorptive qualities. ***A secondary dressing*** is placed over a primary dressing to provide further protection, absorptive capacity, compression, and/or occlusion.

Lawrence (1994) classified the wound dressing into 2 main groups, such as traditional wound dressing and modern wound dressing.

2.6.1 Traditional Wound Dressing

Traditional wound dressing, such as gauze, lint and cotton dressing. Gauze dressing can be used as primary, secondary, or securing dressing. It can protect the wound from trauma and infection. Gauze dressing can inhibit wound contraction because these dressings are not highly absorptive. They may require frequent dressing changes and have break-through drainage. These dressings can also adhere to the wound and traumatize healthy tissue upon removal. However, gauze is still the most widely used in the wound care dressing because it is cost-effective and readily available.

2.6.2 Modern Wound Dressing

Since the 1962, the concept of moist wound healing was described by Winter. The modern wound dressing was developed for maintain moist environment and accelerates wound healing. The U.S. pharmacist (2002) classified the new dressing into 3 groups according to its function.

2.6.2.1 Dressings that Absorb Fluid

Absorbent dressing has a high capacity of capturing and holding to fluid, required fewer dressing changes as opposed to gauze dressing (non-absorbent). The absorbent dressing such as :

Foam dressing

Foam dressing are most often polyurethane in composition. The contained fluid in foam also maintains a humid environment for the cells at the wound surface, promoting moist wound healing and prevents dehydration. The advantages of foam dressing are non-adherent, may repel contaminates, are absorptive and may be used under compression. They are also easy to apply and to be removed. Disadvantages of foam dressing are not effective for wounds with dry eschar and can macerate the periwound area if they become saturated with exudate. They may reguire a secondary dressing. Examples of wound dressing such as Polymem, Lyofoam, Allevyn.

Collagen dressing

Collagen is the most abundant protein in the body and is available in sheet, powder and gel form. The advantages of collagen dressing are absorbent, maintain a moist wound environment, and can be used in combination with topical agents. They are non-adherent, easy to apply and remove. Disadvantages of collagen dressing are not recommended for third degree burns or black wounds and require secondary dressing. Examples of collagen dressing such as Fibracol, Skin Temp sheets.

Calcium alginate dressing

Alginates are polysaccharide derived from brow seaweed. The advantages of alginate fibers have a very high absorbent capacity; upon absorption of wound fluid they swell and become gel and create a moist wound environment, facilitate autolytic debridement and fill in dead spaces. They are easy to apply and remove. Disadvantage of alginates, they are not recommended for wounds with light exudate or dry eschar. They can dehydrate the wound bed and required a secondary dressing. Examples of calcium alginate dressing such as Sorbsan, Kaltostat, Carra Sorb.

2.6.2.2 Dressing that Protect and Maintain Wounds.

As wounds progress in healing and begin to granulate or fill in with new connective tissue, their exudate production lessen and dressing absorbency become less important. As mentioned above, when the exudate levels decrease, continued use of an absorbent dressing may actually dehydrate the wound tissues. At these phase of healing, it is needed a maintenance of natural moisture level of the newly forming tissue without active absorption. Two types of dressing that provide this function are transparent film and hydrocolloid dressing.

Transparent film dressing

Transparent film dressing is a thin, transparent sheet of a polymer (polyurethane), which has been coated on one side with adhesive. The advantages of transparent film dressing are waterproof, no ability to absorb fluids, permeable to water vapor, oxygen, and other gases, but are impermeable to water and bacteria. Transparent films aid in maintaining a moist environment and promote formation of granulation tissue and autolytic debridement of necrotic tissue. They do not require a secondary dressing. Disadvantages of this dressing are not recommended for wounds with moderate to heavy drainage and should not be used on infected wounds. They are sometimes difficult to apply and should not be used over areas of fragile skin. Examples of transparent film dressing such as Op-site, Bioclusive, Tegederm.

Hydrocolloid dressing

Hydrocolloid dressing is composed of two layers, the outer layer is made of a polyurethane foam or film, that is a waterproof, impermeable to gas, water vapor and bacteria. The inner layer is made of hydrophilic particles, such as gelatin and pectin (Foster *et al.*, 1995), when place on a wound the particles combine with the exudate and form a soft moist gel. The advantages of hydrocolloid dressing have the ability to absorb small amount of wound exudate to provide a moist environment. Hydrocolloid is strong adhesive, the dressing should not be changed frequently, this leads to minimal skin trauma and disruption of healing. Disadvantages of hydrocolloid are not recommended for wounds that are heavily exudative or infected,

surrounded by fragile skin, or wounds with exposed tendon or bones. If they are opaque, wound assessment can be difficult. With a havily eaudative wound, the dressing become dislodged and the periwound area can become macerated. Examples of hydrocolloid dressing such as Duoderm, Intrasite.

2.6.2.3 Dressing that hydrate dry wounds and facilitate autolytic debridement such as hydrogel dressing.

Hydrogel dressing

Hydrogel dressing is transparent polyethylene membrane whose compose of a water content of approximately 96%. The advantages of hydrogel dressing can hydrate the wound bed, facilitate autolytic debridement, allows a cooling effect and reduces pain. They are easy to apply and to remove, provide minimal absorption capability. Hydrogel dressing are indicated in the treatment of partial or full-thickness wound, deep wound and second-degree burns because of the dressing's cool ability. Disadvantage of hydrogel dressing can dehydrate easily if it not covered by a secondary dressing. Because of their high water content, they are not recommended for use on highly exudate wound. They can be maceration of surrounding tissue according to their high water content. Examples of hydrogel dressing such as Vigilon, Elastrogel, Intrasitegel

Some researchers classified the wound dressing into ***occlusive dressing*** is referred to the dressing that does not transmit gases or liquid, such as hydrocolloid, hydrogel. The dressing do allow transmit gases and water vapor is ***semi-occlusive dressing*** such as transparent film. The some of wound dressing are shown in Table 3.

Table 3. Wound dressing modified from Cohen *et al.*, 1999.

Classification	Compositions	Indications	Functions	Examples
Film	Semiocclusive (semipermeable). Polyurethane or copolymer	Acute or chronic. Partial or full-thickness wounds with minimal exudate, non-draining, primary close wound	Water vapor permeable, water/bacterial impermeable. Retention dressing for gel. Provides moist environment for epithelialization	Op-site, Bioclusive, Tegaderm
Hydrocolloids	Contain colloidal particles (gelatic, carboxylmethyl cellulose) in adhesive mass	Acute or chronic. Partial or full-thickness wounds. Stage I to IV pressure ulcers	Absorbs fluid. Debrides soft necrotic tissue by autolysis. Protects wound form trauma. Good adhesiveness without adherence to wound, Promotes reepithelialization	Duoderm, Intrasite
Hydrogels	Contain 80-90% water, Cross-linked polymer such as polyethyleneoxide	Acute or chronic or partial or full-thickness wounds with minimal exudate. Stage I to IV pressure ulcers	Creates moist environment. Requires secondary dressing Low absorbency. Decreases pain, Do not adhere to wound	Vigilon, Elastogel, Intrasite - gel
Foams	Either hydrophilic or hydrophobic, Non-occlusive. Polyurethane or gel film coated., high absorbency	Acute or chronic or partial or full-thickness wounds that are highly secreting	Debrides. High absorbency rates. Water vapor permeable	Polymem, Lyofoam, Allevyn
Calcium alginate	Non-woven composites of fibers from calcium alginate, a cellulose like polysaccharide	Partial or full- thickness Wounds with high exudate	Highly absorbent. Dressing materials becomes a gel to facilitate moist healing. Requires secondary dressing	Sorbsan, Kaltostat, Carra Sorb
Impregnates	Fine mesh gauze impregnated with moisturizing. Antibacterial, or bactericidal compounds. Non-adherent	Acute or chronic partial thickness wounds with minimal to moderate exudate	Does not adhere to wound. Promotes reepithelialization. Requires secondary dressing	Aquaphor-Gauze, Biobrane