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A Comparative Study of Hydrocolloid(Duoderm®) and Hydrogel(Nu-Gel®) Occlusive Dressing Materials in the Treatment of Full-Thickness Skin Wound in Dogs

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Abstract : This study was performed to compare the effects of hydrocolloid(Duoderm®, HC in this study) and hydrogel (Nu-Gel®, HG in this study) occlusive dressing materials on degree of exudate, wound contraction, epithelialization, and healing of full-thickness skin wounds in dogs. Three wounds measuring 2×2 cm in size were created bilaterally(6 wounds/dog) on the dorsolateral aspect of the trunk of 12 dogs. In each dog, the wounds were treated with HC, HG, and normal saline, respectively. For a 4 week period, the wounds were evaluated gross aspects and histopathological aspects. There were no statistically significant differences between treatment groups in percentage of wound contraction, percentage of epithelialization, and percentage of wound total healing during the first week. Significant differences were first detected on day 14. On day 14($P<0.01$) and 21($P<0.05$), mean percentage of epithelialization of HG-treated wound was significantly greater than those in HC- and normal saline-treated wound. Mean percentage of wound contraction of HG-treated wound was significantly greater than that in HC- and control wounds on day 21($P<0.05$). On day 21, mean percentage of wound healing of HG-treated wound was significantly greater than that in HC- and control wounds($P<0.02$). On day 1, 4, and 7 after wound creation, although severe infiltration of PMN (polymorphonuclear leukocyte) cells in HC- and control wounds were observed in the subcutis and moderate infiltration of PMN cells in HG-treated wound were observed in the subcutis, we did not detect significant differences. On day 14 after wounding creation, in the wounds treated with HG dressing, epithelial cells were found over the surface, and edema further decreased in the tissue under the wounds, and the granulation tissue was replaced with collagen fibers. On day 21 after wound creation, in HG-treated wound compared with other experimental material-treated wounds, regenerated epidermis covered most of the wound surface, and the granulation tissue was more replaced with collagen fibers than that on day 14. Overall results indicated that the use of hydrogel dressing materials(Nu-Gel®) as hydrocolloid dressing (Duoderm®) materials and normal saline treatment on full-thickness skin wounds in dogs increased the rate of healing at repair stage.

Key words **:** hydrocolloid, hydrogel, full-thickness wound, wound healing, dog

Introduction

Wound dressing has been reported to play an important role in the different phases of the process of wound healing in the moist or dry environment[8,11,14]. This process is characterized by an orderly sequence of events involving infiltration of specific cells into the wound site. The combined actions and interactions of these cells result in the closure of the wound. The process of wound healing can be divided into four stages: firstly, hemostasis and inflammation stage; secondly, debridement stage; thirdly, repair stage with fibroblasts/capillary ingrowth, wound contraction, and epithelialization; fourthly, maturation stage. This process is continuous, and overlapping of the various stages[7].

In veterinary practice, most wounds in dogs are traumatic in origin, and are contaminated or infected at the time of referral for treatment[23], In these wounds are managed as open wounds, and are healed by contraction and epithelialization. It has been suggested that healing of an open wound will occur more quickly if it is covered with a dressing materials. Until now, advantage of occlusive dressings for treatment of open wound has been emphasized[2,3,12-14,20,24,26,27,34-36]. Although many topically applied agents have been used to treat open wounds, selection of the proper dressing material may affect the rate of wound healing. Occlusive dressings prevent exudate loss from the surface of the wound, are act as a physical barrier to inhibit infection by bacterial pathogens, accelerate the inflammation, and increase the rate of epithelialization[2,3,27]. They are permeable to atmospheric oxygen, but do not allow bacteria or exogenous fluid to reach the wound[2,4,21]. Since their introduction in 1962, occlusive dressings have been documented to decrease the total healing time of full-thickness wounds in human beings by promoting moist wound healing[20,44].

Occlusive dressing materials are broadly classified as biological or synthetic. Although synthetic occlusive dressings have several beneficial properties that enhance wound healing, their overall performance has been reported to be inferior to that of biological occlusive dressings[32]. Biological occlusive dressings, such as porcine xenografts and cadaver allografts, are frequently used in human beings, but are infrequently used in veterinary medicine principally because of their exorbitant cost and lack of availability[18].

Hydrocolloid dressing is an occlusive nonadherant hydrocolloid bandage material with a polyurethane backing. These

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bandages are indicated for covering wounds in the repair stage of wound healing-that is, wounds with an established granulation tissue bed, stimulated contraction, decreased fluid production, and the beginning of epithelialization[38].

Hydrogel dressing(Nu-Gel®, Johnson and Johnson Medical, Division of Ethicon Inc., HG in this study) is an occlusive hydrogel bandage material. These bandages are indicated for covering wounds in the repair stage of wound healing, when they have a healthy bed of granulation tissue and decreased fluid production, and are beginning to epithelialization. Hydrogels have also been described for use over noninfected eschars to soften and aid in their removal[39].

Although these occlusive dressings have been shown to be effective in wound healing, there has been few study performed about comparison of these two occlusive dressing materials.

So, the purpose of this study was to compare the effects of an occlusive hydrocolloid dressing and an occlusive hydrogel dressing on the healing of full-thickness skin wound in dogs.

Materials and Methods

For four week adaptation period, all dogs were exterminated by anthelmintics(Rintal® tabs, Bayer Korea Ltd., Korea) and were vaccinated with DHPPL(Vanguard puppy® Pfizer Inc.). All dogs were maintained in water and solid-feed by free feeding, and discontinued before one day of laboratory work. Throughout the study all dogs had a good appetite, nor did they show signs of discomfort.

Experimental Set-up and Wound Creation

Twelve healthy adult mixed breed dogs(9 female, 3 male, mean body weight 3.50±0.5 kg) were used. Nine dogs were assigned for gross aspects, and three dogs were assigned for histopathological aspects. On day 0, dogs were administrated atropine sulfate(Atropine®, Dai Han Pharm. Co., Korea., 0.05 mg/kg, SC). After ten minutes, anesthesia was induced with xylazine hydrochloride(Rompun®, Bayer Korea Ltd., Korea., 1.1-2.2 mg/kg, IM) and maintained with ketamine(ketamin®, Yuhan Co., Korea., 11 mg/kg, IM). Each dog was positioned in sternal recumbency. Hair over the dorsal aspects of the trunk, from the caudal borders of the scapula to the folds of the flanks and half way to the ventral midline, was removed by use of electric clippers, and was prepared circumferentially for aseptic surgery. A plastic film template was constructed so that 2×2 cm wounds creation. Three 2×2 cm square full-thickness skin defects including the underlying cutaneous trunci muscle were created bilaterally, using a No. 15 scalpel blade. The defects on each side were centered between the caudal border of the scapula and the tuber coxae, with 4 cm between defects and each being 6 cm ventrolateral to the dorsal midline. The skin defects were designated by their location as left cranial, left middle, left caudal, right cranial, right middle and right caudal. Immediately after surgery, the wounds were filled with autoclaved gauze to absorb free blood and stop bleeding.

Wound Treatment

Treatment was randomly assigned. In each dog, two wounds were treated with hydrocolloid dressing (Duoderm®, Conva-Tec, A Bristol-Mayer Squibb Company, HC in this study), hydrogel dressing (Nu-Gel®, Johnson and Johnson Medical, Division of Ethicon Inc., HG in this study), and normal saline (0.9% NaCl Inj., Dai Han Pharm. Co., Korea, control), respectively. Three treatment groups were established immediately after the wounds were created(day 0). All wound dressing materials were nonadherent, so covered with flexible dressing fixation fabric sheet(Mefix®, Molnlycke Health Care LTD). The occlusive dressings were changed every 4 to 7 days according to the manufacture's criteria, or sooner if wound fluid was noted penetrating the bandage. If not, bandage changes also were performed in association with wound tracing schedule. Bandage changes followed the outlined protocol in which a bandage was soiled, had slipped, or was partially removed by individual dog. In such cases, the dogs were restrained and the bandages were repaired and the dressings were replaced if necessary. Crisscross bandage strips were placed between the forelimbs and attached to the body bandage to prevent the bandage from slipping caudally. Elizabethan collars were used to keep the dogs from damaging the bandages. Cotton-padded casting material was placed as a neck brace on each dog to prevent self-inflicted bandage or wound disruption. To avoid infection, the animals were injected twice with Bytril®(Bayer Korea Ltd., Korea., 2-4 mg/kg, IM) on the day of surgery and two days after.

Wound Evaluation

Generally, the wounds were evaluated over a 4-week period. For this study, the results are given only for the first 4 weeks because all treated-wounds were healed after this period except control wounds. Postsurgical gross aspects evaluations were done on day 0, 7, 14, 21 and 28. All wounds were constructed by OHP film(PC82-T1®, SKC), and were analysed by Color Image Analyser Q520(Meta morph, Cambrige Instrument, UK). On each evaluation day, the dogs were sedated with xylazine hydrochloride(Rompun®) and ketamine(ketamin®) using the previously noted doses. The dressings were removed and excessive debris was cleaned from each wound with a sterile gauze pad.

The initial wound area(W_0), wound area on the day measured(W_i), and area of unepithelialized graulation tissue(U_i) were measured(Fig. 1). Mean percentages of wound contraction, epithelialization, total healing(percentage of contraction plus percentage of epithelialization were calculated, using the follow formulas:

$$\text{Percentage of wound contraction} = 100 \times [(W_0 - W_i)/W_0]$$

$$\text{Percentage of epithelialization} = 100 \times [(W_i - U_i)/W_0]$$

$$\text{Percentage of wound healing} = 100 \times [(W_0 - U_i)/W_0]$$

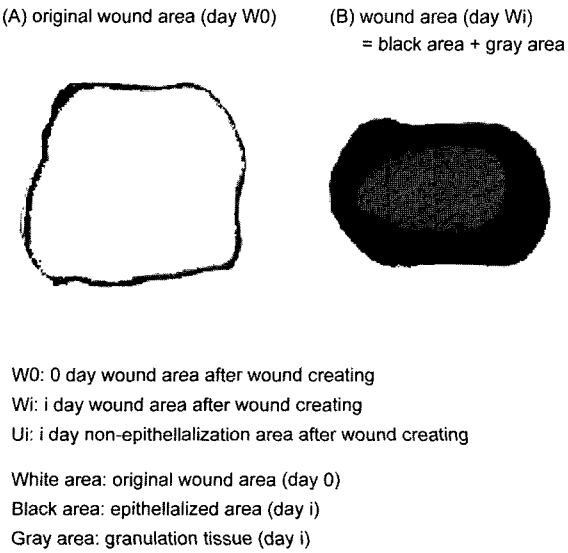

Fig 1. Method for measuring changes in wound size(OHP-film photo)

Wound Biopsy and Histopathological Findings

On day 1, 4, 7, 14, 21 and 28 after wound creation, surgical biopsies were taken under general anesthesia from HG-treated wounds, HC-treated wounds, and control wounds of one dog(three tissue samples were taken each day).

The dogs were anesthetized as previously described, and a 4~5 mm wide longitudinal strip of tissue, including normal skin proximal and distal to the wounds, was removed from the central wound area. Sample tissue was excised from the wound margin to the centre of wound over the full-thickness skin. The tissue samples were fixed in 10% neutral buffered formalin and embedded in paraffin. Each sample was sectioned at 4 μm and was stained with hematoxylin-eosin (H&E) to assess the organization of the epithelial and dermal cellular components.

Statistical Analysis

All data were reported as mean ± standard deviation unless otherwise indicated. Data were compared among groups, using the student t-test. The statistical significance of the differences among HG-treated wounds, HC-treated wounds, and control wounds in gross aspects(wound contraction, epithelialization, and total healing) and in histopathological aspects (degree of PMN cells, fibroblasts, collagen fiber, and epidermis regeneration) were analysed. P value less than 0.05 were considered to be significant($P < 0.05$).

Results

During the first week, both occlusive dressings were changed every 2 days, because of wound fluid leaking from the confines of the dressing. Control wounds were everyday applied with normal saline during the first week. 20 of 24 normal control wounds were dry with a scab forming on top. And despite using tape over the dressings to prevent them from slipping on the wound surface, 4 of the 5 wound dressing materials had a tendency to slip. The greatest frequency of slippage was associated with the HG-treated wounds(22 incidents), especially during the second week of treatment period. But, despite this slippage, those dressings usually remained in contact with the wound.

During the first week of treatment, removal of both occlusive materials on treated and control wounds were caused hemorrhage. All HC-treated and control wounds were associated with moderate to extreme amounts of purulent exudate after day 2. Slight to moderate amounts of purulent exudate were present under the bandages in HG-treated wounds. Hemorrhage at dressing removal decreased markedly after the first week in all wounds.

During the second week of treatment, the occlusive bandages had excessive fluid production at all wounds. But fluid was less than that of first week, so bandages were changed every twice a week. The HC dressing was malodorous and tenacious and difficult to remove from the intact skin, whereas the HG dressing was easier to remove from the intact.

There were no statistically significant differences between treatment groups in mean percentage of wound contraction, mean percentage of epithelialization, and mean percentage of wound total healing during the first week.

Assessment of Wound Healing in Gross Aspect

Differences were first detected on day 7, when mean percentage of epithelialization of HG-treated wounds were higher than those of HC-treated wounds and control wounds. However it was not significant differences($P=0.06$). On day 14 and 21, mean percentage of epithelialization in HG-treated wound was significantly greater than those of HC-treated and control wounds. Throughout treatment periods, mean percentage of epithelialization of occlusive dressing-treated wounds were greater than that of control wounds. But significant differences were not detected in HC-treated wounds compared with control wounds. Wound epithelialization of HG-treated wounds developed rapidly compared with that of HC-treated and control wounds from day 7 to day 14, whereas epithelialization of HC-treated and control wounds developed slowly compared with that of HG-treated wounds. On day 28, there was no significant difference among all 3 dressing materials(Fig 2).

Regardless of the dressing used, all wounds contracted rapidly from day 7 to 14, and contracted slowly from day 14 to 21. Mean percentage of wound contraction of HG-treated wounds were significantly greater than those of HC-treated and control wounds on day 21. From day 21 to 28, mean percentage of wound contraction of HG-treated wounds were slowly decreased than those of HC-treated and control wounds, but significant differences were not founded. Although mean percentage of wound contraction of HC-treated and control wounds were lower than that of HG-treated wound, mean percentage of wound contraction of

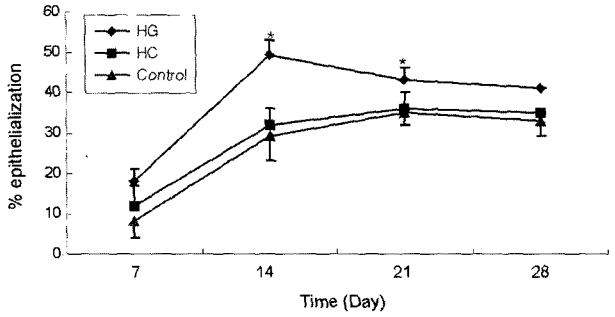

Fig 2. Mean percentage of epithelialization in the wounds treated with Nu-Gel®(HG), Duoderm®(HC), and normal saline (Control). Mean °æ standard deviation.
*: The HG-treated wound is significantly different on day 14($P < 0.01$) and 21($P < 0.05$).

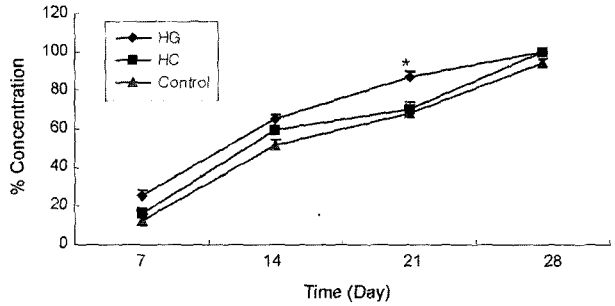

Fig 3. Mean percentage of wound contraction in the wounds treated with Nu-Gel®(HG), Duoderm®(HC), and normal saline (Control). Mean± standard deviation.
*: The HG-treated wound is significantly different on day 21($P < 0.05$).

HC-treated and control wounds were continuously increased from day 21 to 28(Fig 3).

On day 21, mean percentage of wound healing of HG-

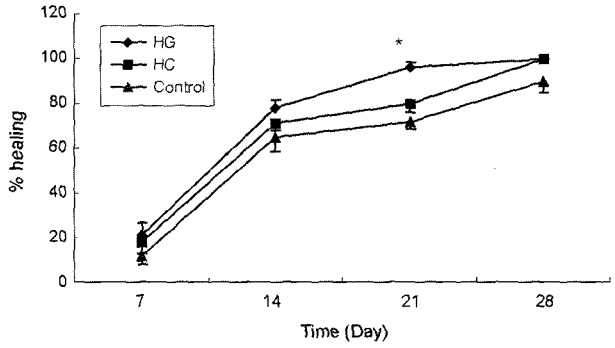

Fig 4. Mean percentage of wound contraction in the wounds treated with Nu-Gel®(HG), Duoderm®(HC), and normal saline (Control). Mean± standard deviation.
*: HG-treated wounds were significantly different on day 21 ($P < 0.02$).

treated wounds were significantly greater than those of HC-treated and control wounds. Regardless of the dressing used, all wounds healed rapidly from day 7 to day 14, and healed slowly from day 14 to 21. On day 28, all occlusive dressing-treated wounds were completely healed, but 9 of the 18 control wounds were not completely healed(mean percentage of wound healing=84%). It was no longer bandaged and sutured by general method after removing granulation tissue(Fig 4).

Assessment of Wound Healing in Histopathological Aspect

On day 1, 4, and 7, severe infiltration of PMN (polymorphonuclear leukocyte) cells of the HC-treated and control wounds were observed in the subcutis, moderate infiltration of PMN cells of the HG-treated wounds were observed in the subcutis. But we did not detect significant differences in any histopathologic variable measured both two occlusive dressing-treated wounds and control wounds(Photo 1). In all wounds, the formation of granulation tissue was observed at the rim

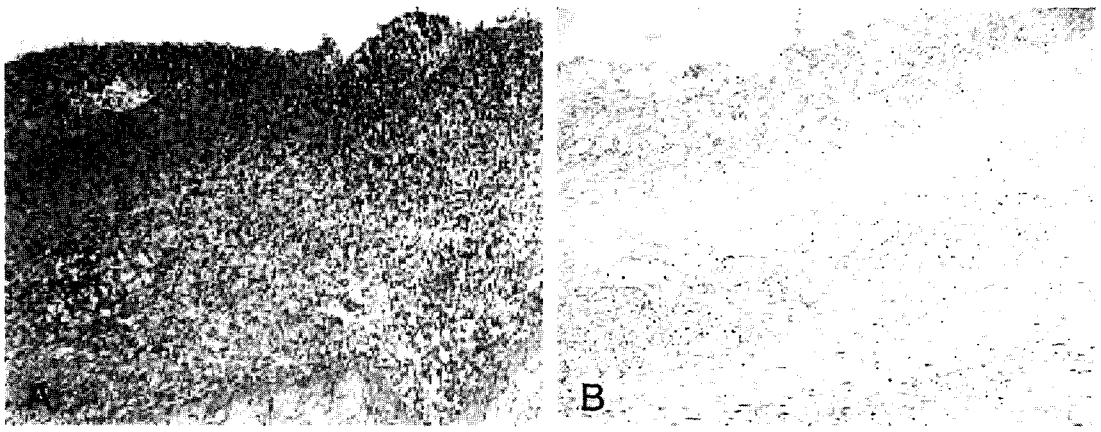

Photo 1. Histopathological findings of granulation tissues after wound creating at day 4. (A) Severe infiltration of polymorphonuclear leukocyte(PMN) in HC-treated wounds(× 100). (B) Mild infiltration of polymorphonuclear leukocyte(PMN) in HG-treated wounds (× 100).

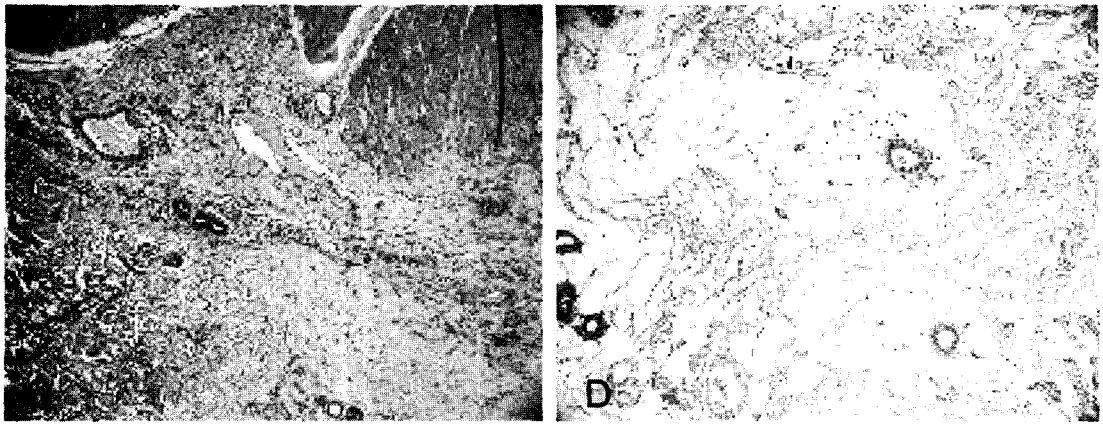

Photo 2. Histopathological findings of granulation tissues after wound creating at day 14. (C) Fibroblasts proliferation and collagen density were much observed in HG-treated wounds(× 200). (D) Only a few fibroblasts proliferation and collagen density were observed in HC-treated wounds(× 200).

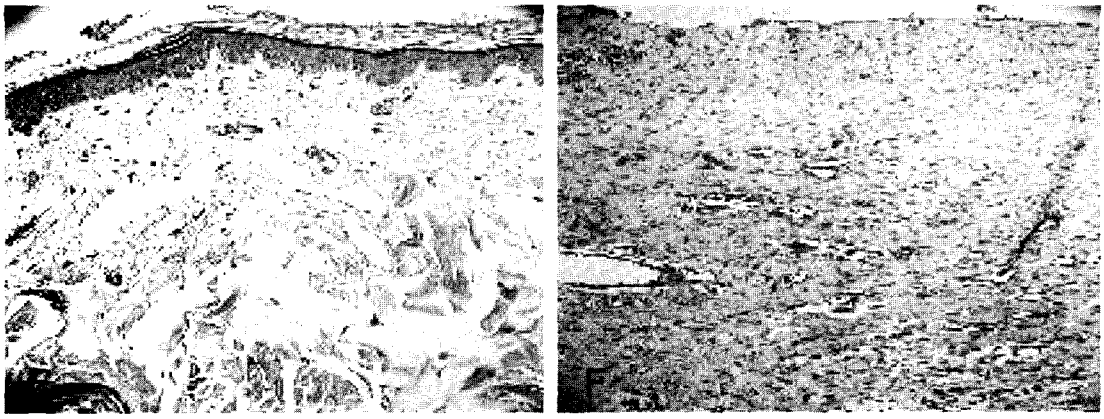

Photo 3. Histopathological findings of granulation tissues after wound creating at day 21. (E) Regenerated epidermis almost covered the wound surface, and the granulation tissue significantly had been more replaced by collagen fiber than that of at 14 day after wound creating in HG-treated wounds(× 100). (F) The growth of epithelial cells from around the skin tissue was more observed than that of day 14 after wound creating, and collagen fiber had more replaced the granulation tissue than that of day 14 after wound creating in HC-treated wounds(× 100).

of the intact skin tissue, but epithelialization was little observed. These results did not indicate significant differences of each treatment wound.

At day 14, in HG-treated wounds, epithelial cells had significantly grown over the surface, edema further decreased in the tissue under the wound, and granulation tissue was replaced by collagen fibers. In contrast, inflammatory granulation tissue had grown to cover the surface of the subcutis, still edematous and little collagen fiber had started to replace the granulation in HC-treated and control wounds(Photo 2). The number of inflammatory cells were decreased in all experimental wounds, but significant differences were not founded.

At day 21, in HG-treated wounds compared with other experimental materials-treated wounds, regenerated epidermis significantly almost covered the wound surface, and the granulation tissue significantly had been more replaced by collagen fiber than that of on 14 day. The inflammatory cells were a little observed in HG-treated wounds. In contrast, the growth of epithelial cells from around the skin tissue was more observed than that on day 14, and the granulation tissue was more replaced by collagen fibers than that on day 14 in HC-treated and control wounds(Photo 3).

At 28 day, both HC-treated and HG-treated wounds were completely healed, but control wounds were not yet completely healed. However they were no longer bandaged and were allowed to heal by second intention.

Discussion

There are many types of bandage materials, many different manufactures, many of which manufacture the same gen-

eral class of bandage materials. Also, many study was investigated about the effects of stimulus agents for skin wound healing, and conflicting results were showed.

Bandages are usually composed of three layers, each with specific properties and function. The contact(primary) layer rests on the wound. Depending on the stage of healing, it can be used to debride tissue, deliver medication, transmit wound exudate, or form an occlusive seal over the wound. Also It may be adherent or nonadherent. Adherent bandages are preferred if the wound is in the inflammatory or debridement stage of healing, but nonadherent bandages are preferred if it is in the repair stage[37].

The traditional method of bandaging open wounds in small animals is to use absorbent dressings to draw wound fluid away from the wound surface into the bandage. This may be accomplished with an adherent wet-to-dry contact layer in the initial stages of wound treatment which aids in debridement of superficial debris[40].

Occlusive dressings are currently used extensively to treat wounds in humans[28]. These occlusive dressing materials are nonadherent bandages, and are retain enough moisture to prevent tissue dehydration and promote epithelialization while allowing excess fluid to be absorbed from the wound. Wound fluid may contain substances that increase the rate of wound healing. Also, increased rates of healing in wounds treated with occlusive dressings have been reported in humans and experimental animals[2,10,19,33,44]. Possible disadvantages of occlusive dressings include increased bacterial growth and increased tissue maceration in the moist environment[31]. In this study, however, we are only investigate the effect of full-thickness skin wound healing. So this study does not report disadvantages of the occlusive dressings. Up to the present, much of the research into occlusive dressings has been reported on partial-thickness wounds[2,3,12,17,43,44]. And some studies that did evaluate occlusive dressings for the treatment of dermal repair reported different results[2,3,25,43]. Although experimental designs were similar to this study, no studies have evaluated that comparison the effects of a hydrocolloid occlusive dressings with the effects of a hydrogel occlusive dressings on the healing of full-thickness skin wound in dogs.

Based on the results of this study, it appeared that the hydrogel dressings most accelerated epithelialization in full-thickness skin wound during day 14 to day 21 among three experimental materials. Epithelialization was shown to start earlier, as it has already been reported for the epithelialization of partial-thickness wounds[9-13,20,22,43,44]. When considering the type of healing that occurred, the HG-treated wound had a greater percentage of wound area covered by advancing epithelium than HC-treated and control wounds. Epithelium will migrate across granulation tissue in a layer if there is no impediment such as an exudate. If impediment is present, thickness or wedge of migrating epithelium is observed[42]. This wedging migrating epithelium was observed histopathologically in HC-treated and control wounds. This may have been associated with moderate to extreme amounts of purulent exudate under both HC-treated wounds and control wounds.

HG-treated wounds had a significantly greater percentage of wound area healed by contraction on day 21. Throughout wound healing time, wound contraction is more important than epithelialization, because wound contraction functions a tough covering of full-thickness skin. So wound contraction, together with epithelialization, contribute to wound healing, and demonstrate beneficial effect of repair stage of wound healing. In addition, the adhesive nature of the HC dressing has been postulated to delay wound contraction by sticking to the wound edges and physically opposing the centripetal pull of the myofibroblasts in the granulating wound[24]. The HG dressing has more fluid in nature and did not stick as readily to the wound margins. It can be explained for the differences in rate of mean percentage of wound contraction between HG-treated wounds and HC-treated wounds.

Wound healing was considered complete when epithelialization was 100% and the area of granulation tissue was zero. Thus, wound healing was most affected by wound contraction and epithelialization. It was pronounced previous paragraph. Generally, wounds that were not completely healed by the end of the study(day 28) and were no longer bandaged and were allowed to heal by second intention. In this study, the occlusive dressing-treated wounds were completely healed on day 28, but the normal control wounds were not completely healed on day 28. It may be associated with fast wound contraction and epithelialization.

Some reports suggested that functional properties of the occlusive dressings materials, especially the oxygen permeabilities, affects optimal collagen synthesis[16], a minimum of 20 mmHg of oxygen tension is required. Two occlusive dressing materials are differ from oxygen permeabilities[45]. and some study reported that HC dressing is not permeable to oxygen and carbon dioxide41. In this study, such property might be showed by mean percentage of epithelialization in HG-treated wounds was greater than those of HC-treated wound, but this nature was not demonstrated in this study. Thus, further investigations are necessary to assess the effects of these differences on wound healing in dogs.

In this study, microscopic analyses revealed that the tissue under the wound both HC-treated wounds and control wounds were highly edematous in early to middle stage of wound healing, whereas HG-treated wounds were showed it in the early stage of healing and rapidly disappeared thereafter. This difference suggests that HG-treated wounds have a better capacity to drain exudate from wounds than that of HC-treated and control wounds. Edema, caused by the retention of exudate, induces disorders in the bloodstream and the migration of neutrophils, which, in turn, may delayed wound healing[6]. Based on this finding, although we have no direct evidence, we believe that HG dressing has the ability to retain water, proteins, and electrolytes. This retention may keep the concentrations of important substances such as transforming growth factor(TGF)-α, TGF-β, interleukin(LI)-

Iα, IL-1β, LI-6, keratinocyte growth factor, and other cytokines in the granulation tissue at adequate levels[1,5,15,29,30].

On the basis of results of this study, use of two occlusive dressing materials for initial treatment of full-thickness skin wound healing in dogs cannot be recommended. But The HG dressing materials, as compared with HC dressing materials, may be more beneficial and accelerate epithelialization for treatment of full-thickness skin wounds in the reparative stage of wound healing in dogs. In addition, although these results were limited in this study, the HG dressing materials are to be useful because of readily available, easily prepared and stored, commercially cheaper than HC dressing materials.

Furthermore, we will research the comparative study of the HG dressing materials and other agents to stimulate wound healing in initial stage of full-thickness skin wound healing in dogs. Also further study is indicated to identify and quantify the differences in the wound microenvironment by various wound dressings with the progression of healing.

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개에서 전층피부 창상에 대한 Hydrocolloid(Duoderm®)과 Hydrogel(Nu-Gel®)의 치료 효과 비교 연구

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요 약 : 개의 전층피부 창상에서 삼출물의 정도와 창상수축, 상피화, 그리고 치유에 대해 hydrocolloid(Duoderm®, HC)과 hydrogel(Nu-Gel®, HG) occlusive dressing materials의 효과를 비교하였다. 3쌍의 정사각형 전층피부 창상을 2×2 cm의 크기로 12마리 개의 몸통 등외측 면에(6개의 창상/한 마리) 만들었다. HC와 HG, 생리 식염수(대조창)를 무작위로 배분한 2개의 창상에 각각 적용하였다. 창상의 육안적 소견과 병리조직학적 소견을 4주 동안 평가하였다. 창상 유발 7일 후, 비교 그룹 간의 평균 창상수축 정도, 평균 상피화율, 평균 창상 치유율에 유의성있는 변화가 관찰되지 않았다. 창상 유발 14일($P < 0.01$)과 21일($P < 0.05$) 후, HG 처치창의 평균 상피화율이 HC 처치창의 평균 상피화율과 대조창의 상피화율보다 유의적으로 더 높게 나타났다. 창상 유발 21일 후($P < 0.05$), HG 처치창의 창상 수축율이 HC 처치창의 평균 창상 수축율과 대조창의 평균 창상 수축율보다 유의적으로 더 높게 나타났다. 창상 유발 21일 후($P < 0.02$), HG 처치창의 창상 치유율이 HC 처치창의 평균 창상 치유율과 대조창의 평균 창상 치유율보다 유의적으로 더 높게 나타났다. 창상 유발 1, 4, 7일 후, HC 처치창과 대조창의 피하에 다형핵 백혈구의 심한 침착이 관찰되었고, HG 처치창의 피하에 중등도의 다형핵 백혈구의 침착이 관찰되었으나, HG 처치창, HC 처치창, 대조창 간의 어떠한 유의적인 변화도 발견되지 않았다. 창상 유발 14일 후, HG 처치창에서 상피성 세포가 유의적으로 표면 위로 자라났고, 부종은 창상 밑 조직까지 감소하였으며, 육아조직은 교원질 섬유로 대체되었다. 창상 유발 21일 후, 다른 창상에 비해, HG 처치창은 유의적으로 창상 표면이 거의 재생성 상피로 덮였으며, 육아조직은 창상 유발 14일 후와 비교해서 유의적으로 교원질 섬유로 대체되었다. 위의 모든 결과에서 보듯이, 개에서 전층피부 창상의 처치 시 HG의 사용은 HC와 생리 식염수에 비해 창상치유 복구기의 치유 속도를 촉진하는 것으로 사료된다.

주요어 : hydrocolloid, hydrogel, 전층피부손상, 창상치유, 개