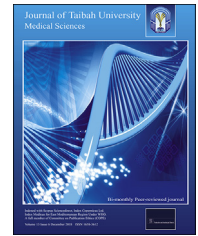




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Experimental Article

## Efficacy of chitosan derivative films versus hydrocolloid dressing on superficial wounds



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### المخلص

**أهداف البحث:** الشيتوزان هو من مشتقات الكيتين، التي تحتوي على خصائص بيولوجية مفيدة مثل التخثر، ومسكن الألم، والتنام الجروح، وتقليل الندبات، ووقف نمو الجراثيم، والتوافق مع الحياة والتحلل البيولوجي. تحدد هذه الدراسة فعالية الغشاء المشتق من الشيتوزان كضماد للجروح السطحية.

**طرق البحث:** أدرج في هذه التجربة العشوائية المحكمة متعددة المراكز ٢٤٤ مريضا. تم علاج ٨٦ مريضا بالغشاء المشتق من الشيتوزان و٨٤ تم علاجهم بغرواني مائي. وتم تقييم النسبة المئوية من تشكل النسيج الظهاري، وراحة المرضى والعلامات السريرية بالإضافة إلى راحة المريض في وضع وإزالة الضمادات.

**النتائج:** النتائج الأولية لهذه الدراسة هي النسبة المئوية من تشكل النسيج الظهاري. لم يكن هناك اختلافات كبيرة بين الجنس، والعمر، واستخدام المضادات الحيوية وحجم الجرح الأولي باستثناء العرق. لم يكن هناك اختلافا ملحوظا في متوسط النسبة المئوية لتشكيل النسيج الظهاري بين المجموعتين. عانى المرضى الذين يستخدمون الغشاء المشتق من الشيتوزان من الألم أثناء إزالة الضماد بالمقارنة بمجموعة الغرواني المائي. أظهرت مجموعة الغشاء المشتق من الشيتوزان إفرات أقل ورائحة أقل بالمقارنة بمجموعة التحكم. بالإضافة إلى ذلك، لم يكن هناك اختلافات كبيرة بين المجموعتين من حيث الالتزام، وسهولة

الإزالة، وتصريف الجرح، والالتهاب الجلدي، والحكة، والألم والضغط. لم يلاحظ أي تورم وحرارة موضعية خلال الدراسة.

**الاستنتاجات:** تستنتج هذه الدراسة أن الغشاء المشتق من الشيتوزان يعادل الضماد الغرواني المائي ويمكن أن يكون خيارا لعلاج الجروح السطحية والتآكل.

**الكلمات المفتاحية:** غشاء الشيتوزان؛ مشتقات الشيتوزان؛ تضميد غرواني مائي؛ الجروح السطحية؛ تآكل

### Abstract

**Objectives:** Chitosan, the N-deacetylated derivative of chitin, has useful biological properties that promote haemostasis, analgesia, wound healing, and scar reduction; chitosan is bacteriostatic, biocompatible, and biodegradable. This study determined the efficacy of chitosan derivative film as a superficial wound dressing.

**Methods:** This multicentre randomised controlled trial included 244 patients, of whom 86 were treated with chitosan derivative film and 84 with hydrocolloid. The percentage of epithelisation, as well as patient comfort, clinical signs, and patient convenience in application and removal of the dressings were assessed.

**Results:** The primary outcome of this study was the percentage of epithelisation. Except for race ( $p = 0.04$ ), there were no significant differences between groups in sex, age, antibiotic usage, or initial wound size ( $p > 0.05$ ). There was no significant difference in the mean epithelisation percentage between groups ( $p = 0.29$ ). Patients

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using chitosan derivative film experienced more pain during removal of dressing than those in the hydrocolloid group ( $p = 0.007$ ). The chitosan derivative film group showed less exudate ( $p = 0.036$ ) and less odour ( $p = 0.024$ ) than the control group. Furthermore, there were no significant differences between groups in terms of adherence, ease of removal, wound drainage, erythema, itchiness, pain, and tenderness. No oedema or localised warmth was observed during the study.

**Conclusion:** This study concluded that chitosan derivative film is equivalent to hydrocolloid dressing and can be an option in the management of superficial and abrasion wounds.

**Clinical trial No.:** NMRR-11-948-10565.

**Keywords:** Abrasion; Chitosan derivative; Chitosan film; Hydrocolloid dressing; Superficial wounds

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## Introduction

Chitosan is a natural biopolymer derived from chitin, a cationic polysaccharide composed of glucosamine and N-acetylglucosamine residues. It is a biodegradable, nontoxic, complex carbohydrate derivative of chitin, a major component of crustacean exoskeletons and cell walls of fungi.<sup>1,2</sup>

In general, the term chitosan is applied when the extent of deacetylation is  $>70\%$  and the term chitin is used when  $<20\%$ . These various grades of chitosan, differing in the degree of deacetylation, have varying effects on its clinical applications.<sup>3</sup>

Chitosan bioderivatives are chemical modifications of chitosan. These modifications are important for the association between bioactive molecules and polymers and control the drug–release profile. Various chitosan derivatives based on chemical modification include N-(aminoalkyl) chitosan; succinyl, quaterminated, and octanoyl chitosan; mitomycin C-conjugated N-succinyl-chitosan; N-alkyl and acylated chitosan; chitosan hydrochloride; thiolated chitosan, and others.<sup>4,5</sup> This study used chitosan as poly-(1,4- $\beta$ -D-glucopyranosamine). This N-deacetylated polysaccharide derived from chitin has valuable properties for biomedical application.<sup>6–11</sup>

Chitosan exhibits antibacterial, antifungal, haemostatic,<sup>12</sup> analgesic, and wound-healing properties<sup>13</sup> and promotes scar reduction. Chitosan is bacteriostatic, biocompatible, and biodegradable, with potential use as a wound dressing material.<sup>14</sup>

The need for an ideal wound dressing has long been recognised. In 1963, Scales wrote that ideal dressings should have high porosity to water vapour and non-adherence to

blood clot or a granulating surface, and should permit penetration of capillary loops, absorb free blood exudate, act as a barrier to the passage of microorganism, and follow the wound contour. Dressings should not produce tissue reactions, should not be inflammable, and should be capable of being sealed to the skin. They should be sterilisable and available at a low cost.<sup>15</sup>

In recent studies, a wide variety of derivatives such as chitosan hydrogel and chitosan/sodium alginate revealed different swelling behaviours. Chitosan hydrogel containing lignin nanoparticles had a synergic antimicrobial effect, making it useful in wound dressing, food packing, and drug delivery applications.<sup>50,51</sup> A variety of dressings are available, suggesting that no one dressing material can be considered suitable for all types of wounds. Wound dressings are generally classified as passive, interactive, or bioactive products with active compounds that aid in wound healing. Chitosan is one such biomaterial.

A collaboration with SIRIM Malaysia and the Malaysian Nuclear Agency developed several wound dressing products based on chitosan bioderivatives in the form of a film, sheet, and paste for various clinical applications on wounds. The study materials were produced by SIRIM Malaysia at their pilot plant in Sepang (SIRIM incubation centre), which is a Good Manufacturing Practices (GMP)-compliant facility. The chitosan derivative produced for this clinical trial consisted of 70% chitosan and 30% glycerol.

Extensive preclinical study in a Good Laboratory Practices-certified facility (RMIT Lab) established the biocompatibility of these products in vitro and in vivo and confirmed they were acceptable for human use.<sup>6,8,10,16–18</sup>

Few randomised clinical trials have assessed wound dressings. A few prospective randomised controlled trials (RCTs) have been performed on graft skin used to manage noninfected neuropathic diabetic foot ulcers,<sup>19</sup> vacuum-assisted closure versus modern wound dressings,<sup>20</sup> negative pressure therapy after partial foot amputation,<sup>21</sup> vacuum-assisted closure with advanced moist wound therapy for diabetic foot,<sup>22</sup> and a few studies have examined hydrocolloid dressings.<sup>23–26</sup> To the best of our knowledge, this is the first prospective study on chitosan derivative film in comparison with hydrocolloid for use on superficial wounds. A previous RCT on bioactive dressings containing hydrophilic mucopolysaccharide used chitosan to treat diabetic foot ulcers, pressure ulcers, and leg ulcer.<sup>27</sup> Chitosan derivatives have also been studied extensively in vitro and in vivo (using animal models) and have been used as haemostatic agents.<sup>6–10,16–18,28–41</sup>

The aim of this study was to evaluate the efficacy of a chitosan derivative film dressing in the treatment of superficial wounds, compared with that of a commercially available hydrocolloid wound dressing material.

## Materials and Methods

This prospective, single-blind, randomised controlled clinical trial compared the efficacy of chitosan derivative film versus hydrocolloid for the treatment of superficial wounds/abrasions in patients attending the Reconstructive Sciences

Unit and Emergency Department at the Hospital Universiti Sains Malaysia and Hospital Universiti Kebangsaan Malaysia.

#### *Chitosan derivative film dressing preparation*

This dressing was manufactured and supplied by SIRIM Malaysia. Their pilot plant in Sepang (SIRIM incubation centre) is a GMP-compliant facility. Preparation of film was produced as described by Ujang and colleagues (2014-in press).<sup>52</sup>

#### *Patient selection*

Patient of both sexes aged between 16 and 70 years who presented to the Accident and Emergency Department of two large medical centres in Malaysia with superficial or abrasion wounds were screened for the study. Patients with severely contaminated or infected wounds, allergy to seafood, uncontrolled diabetes (random blood glucose >10 mmol/L), noncompliance, pregnancy, and any skin pathology (such as eczema) were excluded from the study.

Patients who fulfilled the inclusion criteria were enrolled in the study upon signing a consent form. They were then randomised to 1 of 2 dressing groups by using a random sequence generated with web-based software (<http://www.randomization.com>).

#### *Dressing and application*

The wounds were treated according to usual departmental practice. Once a patient signed the consent form, the wound was cleaned with 0.9% normal saline and 0.5% chlorhexidine. The chitosan derivative film was cut according to wound size with a 1 cm overlap. This dressing was applied to the wound with Hypafix<sup>®</sup>, since it was not self-adhesive. A Hydrocolloid<sup>®</sup> Extra Thin dressing was selected, cut into desired size, and applied directly to the wound in accordance with the manufacturer's instructions.

The dressing was first inspected and changed on days 5 and 7, when the wound was fully epithelised. The wounds were photographed during every wound inspection and before new dressings were applied. Application of chitosan derivative film dressing is shown in [Figure 4](#).

#### *Measurement of outcomes*

Data on patient details and all clinical characteristics were recorded on a case report form. Time until healing (epithelisation percentage), patient comfort (pain and itching), clinical appearance (wound drainage, erythema, localised warmth, and oedema), and convenience in application and removal of dressing (pain upon removal, exudate, adherence, ease of removal, and odour) were all noted. In addition, notes were made regarding allergy and complications caused by the dressings.

#### *Statistical methods*

Data were analysed using IBM SPSS Statistics version 20. Numerical variables were summarised as mean and standard

deviation (SD) or median and interquartile range (IQR), depending upon the normality of data distribution. The categorical variables were presented as frequency and percentage. Differences of means between groups at any particular time were analysed using an independent t-test, and differences of proportion were analysed using the Pearson chi-square test. A repeated-measures independent t-test, and differences in means of epithelisation percentage between chitosan derivative film and Hydrocolloid<sup>®</sup> Extra Thin were determined. The level of significance was set at  $p$  value 0.05.

## **Results**

A total of 244 patients were enrolled in this randomised control trial study from May until October 2012. Of these, 121 (49.6%) received chitosan derivative film (treatment group) and 123 (50.4%) received hydrocolloid (control group) dressings. [Figure 1](#) shows the allocation of subjects into groups. Thirty-five (28.9%) patients from the treatment group and 39 (31.7%) from the control group were not included in the final analysis. There was no significant difference in the proportion of drop-outs between groups ( $p$  value 0.636). Reasons for drop-out in the treatment group were failure to follow up (33 patients) and underlying medical illness (2 patients). In the control group, 36 patients failed to follow up and 3 discontinued participation due to adverse events such as development of an exudative wound. A total of 170 patients completed this study. The data are summarised in [Figure 1](#).

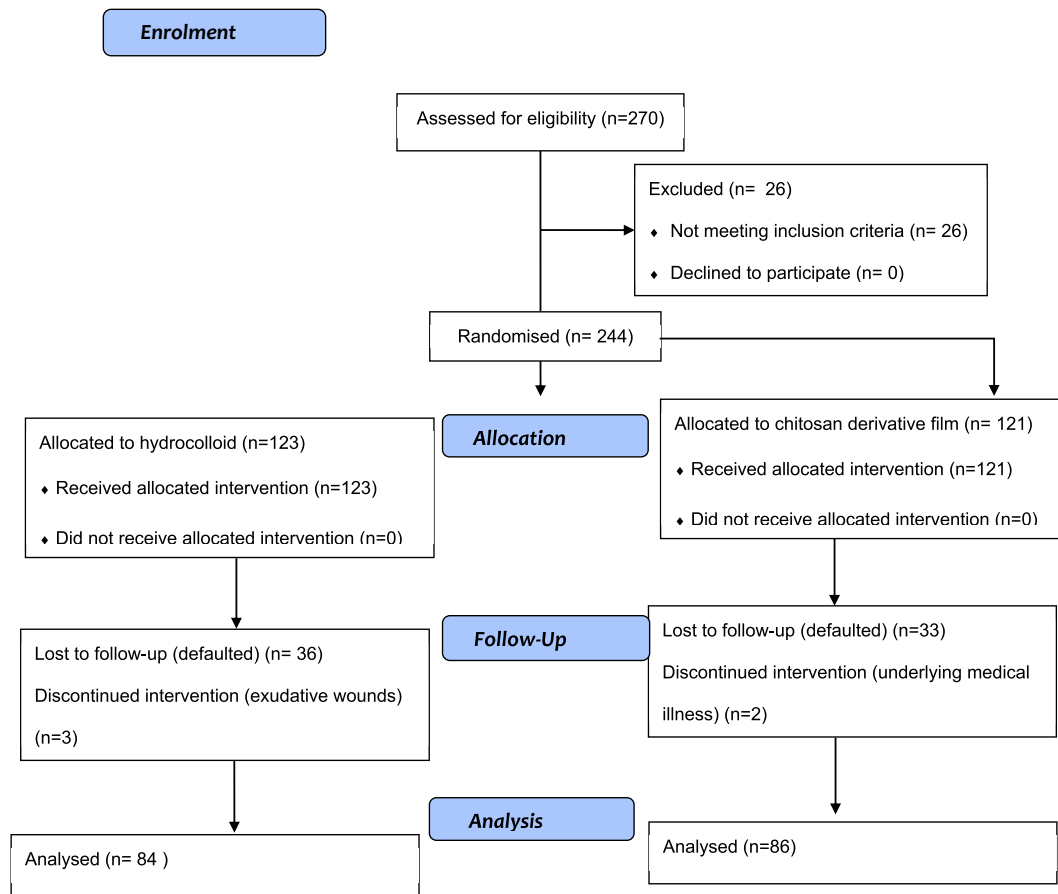
[Table 1](#) shows sociodemographic and baseline data of the subjects. The mean age was 29.79 (SD 13.72) years in the treatment group and 26.12 (SD 11.67) years in the control group. There were 74 (52.1%) males and 12 (42.9%) females in the treatment group and 68 (47.9%) males and 16 (57.1%) females in the control group. Except for race, there were no statistically significant differences between the groups in terms of demographic data and wound size at baseline ( $p = 0.269$ ).

[Figure 2](#) shows that most wounds in both groups occurred on the upper limbs (47.1%), followed by the lower limbs (24.1%), head/neck (23.5%), posterior trunk (3.5%), and anterior trunk (1.8%).

[Table 2](#) and [Figure 3](#) show that there was no significant difference in the mean wound epithelisation percentage between groups [F test (df) = 1.18 (1),  $p$  value 0.290]. The inter-observer agreement among 3 observers for measurement of epithelisation on day 5 ( $n = 104$ ) was 0.582 (95% confidence interval 0.474, 0.679), 0.349 (95% confidence interval 0.129, 0.574) on day 7 ( $n = 31$ ), and 0.197 (95% confidence interval -0.067, 0.525) on day 9 ( $n = 17$ ).

Assessment of patient comfort with the dressing showed satisfaction with both types. [Table 3](#) compares both groups for patient comfort and clinical signs on follow-up days 5, 7, 9, 11, and 13. There was no significant difference in the mean score for itchiness, pain/tenderness, wound drainage, and erythema between both groups. No patients had localised warmth or oedema/induration.

[Table 4](#) compares both groups for convenience of application and removal of dressings. Pain upon removal



**Figure 1:** Flow chart of the trial for completed samples.

was significantly greater in the chitosan group on day 5 due to use of Hypafix to attach the chitosan derivative dressing to the wound, not because of the film itself. In contrast, assessment for exudate and odour showed significantly higher scores in the hydrocolloid group compared to the chitosan group. Slow-healing wounds were more exudative on day 13 and odour was stronger on day 5 in the hydrocolloid group.

## Discussion

This report showed the effectiveness of chitosan derivative film in comparison with conventional hydrocolloid dressing for treating superficial/abrasion wounds. The findings support evidence-based use of chitosan derivatives in clinical practice. The use of film dressings on superficial

**Table 1: Comparison of sociodemographic and baseline data in chitosan derivative film and hydrocolloid groups.**

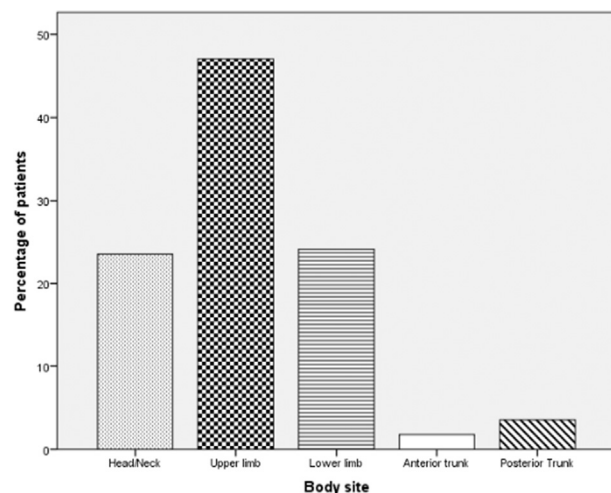
	Chitosan derivative film n = 86	Hydrocolloid n = 84	p value
Age <sup>c</sup> (years)	29.79 (13.72)	26.12 (11.67)	0.062 <sup>a</sup>
Sex <sup>d</sup>			
Male	74 (52.1)	68 (47.9)	
Female	12 (42.9)	16 (57.1)	0.371 <sup>b</sup>
Race <sup>d</sup>			
Malay	74 (48.1)	80 (51.9)	
Non-Malay	12 (75.0)	4 (25.0)	0.040 <sup>b</sup>
Use of antibiotic <sup>d</sup>	12 (44.4)	15 (55.6)	0.486 <sup>b</sup>
Initial wound size <sup>c</sup> (cm)	14.73 (18.18)	11.89 (15.03)	0.269 <sup>a</sup>

<sup>a</sup> Independent t test.

<sup>b</sup> Pearson's chi-square test.

<sup>c</sup> mean (standard deviation).

<sup>d</sup> frequency (%).



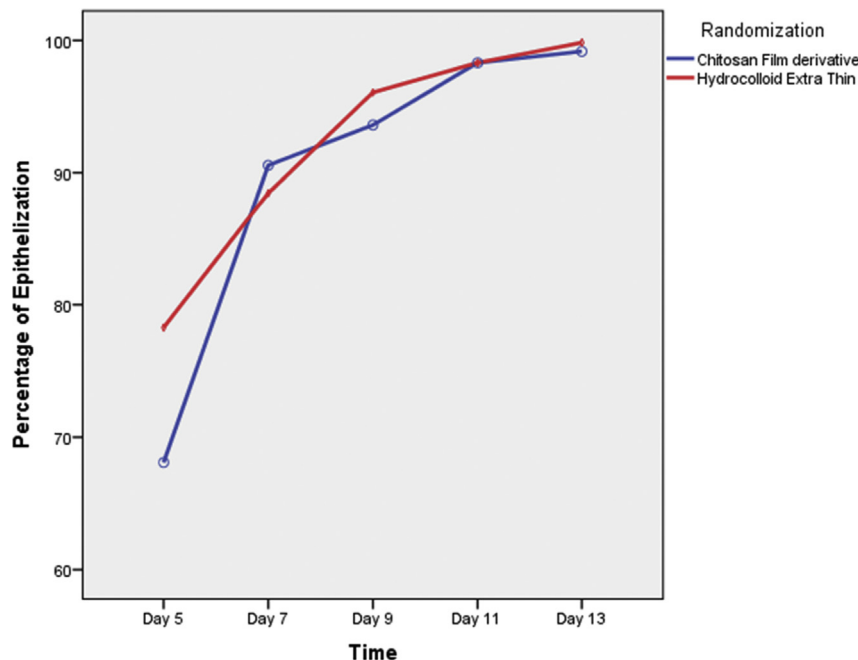
**Figure 2:** Wound sites in both groups.

**Table 2: Comparison of mean wound epithelisation percentage over time between the chitosan derivative film and hydrocolloid groups.**

	Epithelisation Percentage Mean (95% CI)					<i>p</i> value <sup>a</sup>
	Day 5	Day 7	Day 9	Day 11	Day 13	
Chitosan derivative film	68.09 (60.83,75.36)	90.56 (85.18,95.95)	93.61 (89.92,97.29)	98.31 (96.06,100.55)	99.17 (97.99,100.36)	0.290
Hydrocolloid	78.27 (70.93,85.62)	88.46 (83.00,93.91)	96.07 (92.34,99.80)	98.31 (96.03,100.58)	99.84 (98.64,101.04)	
<i>p</i> value <sup>b</sup>	0.053	0.588	0.355	0.999	0.437	

<sup>a</sup> Repeated-measures analysis of variance (ANOVA).

<sup>b</sup> Independent t-test for each time point.

**Figure 3:** Comparison of mean wound epithelisation percentage over time between the chitosan derivative film and hydrocolloid groups.

wounds was supported by Harding et al. This type of dressing is able to transmit moisture vapour from the wound to outside the dressing.<sup>42</sup>

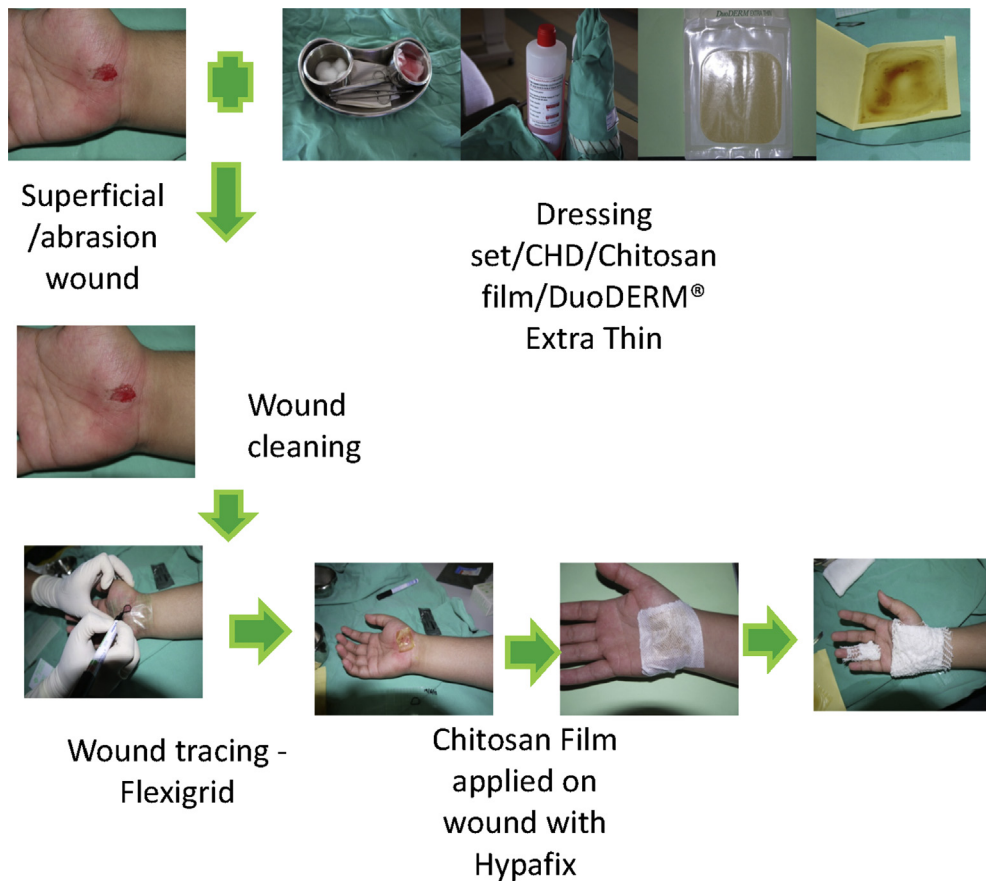
The sociodemographic and baseline patient data in this trial showed no differences except for race. The simple explanation is that Malays comprise the largest population group in Malaysia.

Our sample also showed that most injuries were on the upper limb (47.1%), despite the absence of adverse factors affecting wound healing such as infection and uncontrolled diabetes. Most wounds in this study were caused by motor vehicle accidents.

To evaluate the efficacy of chitosan derivative film dressing in treating superficial/abrasion wounds, this clinical trial focused on wound epithelisation as well as patient comfort, clinical appearance, and convenience in application and removal of dressings. This clinical trial suggested the effectiveness of chitosan derivative film dressings in the epithelisation of superficial wounds. However, it was difficult to prove that one material was superior to the other in terms of wound healing. This is because incisions and abrasions tend to heal in 5–10 days, depending on the site. The overall wound dimensions and other background data showed a

reasonable degree of balance between the groups. Our results demonstrated clearly that there were no problems with healing. Almost all wounds were completely epithelised on day 5 in both treated and control groups ( $n = 104$ ).

Epithelisation is very important in wound healing.<sup>43</sup> The first phase takes place as epithelial cells migrate across new tissue to form a barrier between the wound and environment. This step is initiated by a cascade of inflammatory cytokines, including interleukin (IL)-1 and tumour necrosis factor- $\alpha$ , which upregulate keratinocyte growth factor (KGF) in fibroblasts. This in turn stimulates fibroblasts to secrete KGF-1, KGF-2 and IL-6. These chemicals stimulate and initiate neighbouring keratinocytes to migrate into the wound, resulting in proliferation and differentiation into the epidermis.<sup>44–46</sup> Therefore, the time of onset of migration is variable and may begin about 1 day after injury. Cells at the wound margins proliferate on the second and third day after injury and provide more cells for migration. Therefore, it is important to cover the wound with an effective dressing, not just to prevent contamination or infection but also to secure the epithelisation process. Falanga (1988) proposed that faster epithelisation would occur if the wound remained under



**Figure 4:** Application of dressing.

occlusive dressing, with fluid kept in contact with the wound and not lost to gauze.<sup>47</sup>

The main advantage of both dressings was patient comfort. Once applied, the dressing could remain in place and would not interfere with normal activities. Dressings used in this study could be kept in place for 5–7 days without changing. This is in line with the review by Harding et al.,<sup>42</sup> suggesting that dressings should be durable and not require changing for 4–5 days. Observation on chitosan derivative film in our study also revealed that it will peel off by itself once the wound is healed because chitosan is a biodegradable polymer and does not injure cells.<sup>6,14,17,35</sup> Earlier studies on the effect of chitosan derivative film on proliferation of human skin fibroblasts supported our findings. Chitosan dressing aids the wound healing process in several ways.<sup>6,8,10</sup> The advantages of chitosan as a dressing include its antimicrobial, analgesic, haemostatic, and wound-healing properties, as well as biocompatibility.<sup>14,35,48,50,51</sup> Chitosan also accelerates epidermal regeneration and stimulates granulation and tissue formation.<sup>29</sup> Application of chitosan on an open wound was found to induce significant contraction, thereby accelerating wound closure and the healing process.<sup>33</sup>

From our observation in an earlier dressing assessment, chitosan membrane was found to adhere uniformly to fresh and wet wounds. However, it needed to be secured with Hypafix®, since it is not self-adhesive, whereas the dressing in the control group had self-adhesive properties. The chitosan derivative film dressing remained dry at the first inspection,

with minimal exudate. Wound dryness in both groups gradually increased with time. The wound improved from wet to finally dry when healing was near completion. There was a statistically significant difference in the control group in exudate and odour on day 13 compared to that in the treatment group. The presence of exudate on the wound is critical as it could delay healing. These conditions occur when hydrocolloid produces a viscous mobile gel in the presence of wound exudate.<sup>49</sup> Since the dressing was changed for the first time on day 5, the accumulation of viscous material caused a strong odour and maceration of surrounding skin.

The application of a secondary dressing (Hypafix®) for chitosan derivative film resulted in significant pain upon removal on day 5, but not because of the film itself. In our analysis, the only significant finding was wound exudation and pain upon dressing removal. Other modalities of wound and dressing assessment such as the scoring of pain, itchiness, wound drainage, and erythema, as well as sociodemographic findings, revealed no statistically significant differences between the two groups according to baseline demographic data and wound size ( $p = 0.269$ ).

The evolution of modern dressings has been stimulated by the understanding of phases of wound healing and factors contributing to enhance wound healing. Hydrocolloid, hydrofiber, and silicone-coated dressings, and many other non-stick dressings have been produced with advances in technology. These materials may be used alone or combination with others in the search for an ideal dressing product.

**Table 3: Comparison of patient comfort and clinical signs between both groups on follow-up days 5, 7, 9, 11, and 13.**

Patient symptoms and wound assessment	Scores Mean (95% CI)					p value*
	Day 5	Day 7	Day 9	Day 11	Day 13	
Itchiness						0.686
Treatment	0.93 (0.54, 1.32)	0.06 (-0.05, 0.16)	0.07 (-0.05, 0.19)	0.02 (-0.02, 0.07)	0.00 (-0.03, 0.03)	
Control	0.52 (0.13, 0.92)	0.18 (0.07, 0.29)	0.16 (0.03, 0.28)	0.05 (0.00, 0.09)	0.04 (0.0, 0.06)	
p value	0.147	0.117	0.341	0.461	0.083	
Pain/tenderness						0.337
Treatment	1.02 (0.59, 1.46)	0.15 (-0.00, 0.30)	0.14 (-0.04, 0.32)	0 (0)	0 (0)	
Control	0.71 (0.27, 1.15)	0.12 (-0.04, 0.27)	0.10 (-0.09, 0.28)	0 (0)	0 (0)	
p value	0.324	0.770	0.735	NA	NA	
Wound drainage						0.719
Treatment	0.30 (0.21, 0.40)	0.15 (0.08, 0.23)	0.08 (0.03, 0.13)	0.06 (0.01, 0.11)	0.01 (-0.02, 0.04)	
Control	0.29 (0.19, 0.38)	0.14 (0.07, 0.22)	0.05 (-0.01, 0.10)	0.05 (-0.00, 0.10)	0.02 (-0.01, 0.05)	
p value	0.813	0.879	0.374	0.761	0.549	
Erythema						0.767
Treatment	0.02 (-0.02, 0.06)	0.02 (-0.00, 0.06)	0 (0)	0.01 (0.01, 0.03)	0 (0)	
Control	0.05 (0.01, 0.09)	0.02 (-0.01, 0.06)	0 (0)	0 (0)	0 (0)	
p value	0.394	0.981	0.324	NA	NA	
Localised warmth						NA
Treatment			All absent			
Control			All absent			
p value						
Oedema/induration						NA
Treatment			All Absent			
Control			All absent			
p value						

\*p value for repeated-measures ANOVA between groups.

NA – not applicable.

**Table 4: Comparisons of patient convenience in application and removal of dressing between both groups on follow-up days 5, 7, 9, 11, and 13.**

Dressing assessments	Scores Mean (95% CI)					p value*
	Day 5	Day 7	Day 9	Day 11	Day 13	
Pain Upon Removal						0.007
Treatment	0.85 (0.54, 1.16)	0.26 (0.08, 0.43)	0.02 (-0.02, 0.07)	0 (0)	0 (0)	
Control	0.25 (-0.07, 0.57)	0.06 (-0.12, 0.24)	0.05 (0.00, 0.1)	0 (0)	0 (0)	
p value**	0.008	0.115	0.461	–	–	
Exudate						0.036
Treatment	0.12 (0.01, 0.23)	0.06 (-0.01, 0.13)	0.01 (-0.04, 0.06)	0.00 (-0.04, 0.04)	0 (-0.03, 0.03)	
Control	0.25 (0.14, 0.36)	0.12 (0.05, 0.19)	0.07 (0.02, 0.12)	0.06 (0.02, 0.10)	0.05 (0.02, 0.08)	
p value**	0.095	0.224	0.090	0.058	0.045	
Adherence						0.553
Treatment	0.14 (0.06, 0.22)	0.01 (-0.03, 0.05)	0.04 (-0.00, 0.07)	0 (-0.02, 0.02)	0 (-0.02, 0.02)	
Control	0.12 (0.04, 0.20)	0.06 (0.02, 0.10)	0.02 (-0.01, 0.06)	0.02 (0.00, 0.05)	0.02 (0.00, 0.05)	
Ease of removal						0.466
Treatment	1.06 (1.02, 1.10)	0.25 (0.15, 0.35)	0.17 (0.10, 0.24)	0.06 (0.01, 0.11)	0.01 (-0.03, 0.05)	
Control	1.00 (0.96, 1.04)	0.25 (0.15, 0.35)	0.08 (0.01, 0.16)	0.05 (-0.00, 0.10)	0.05 (0.01, 0.08)	
Odour						0.024
Treatment	0.06 (-0.02, 0.13)	0.02 (-0.02, 0.07)	0.00 (-0.02, 0.02)	0.00 (-0.02, 0.02)	0.00 (-0.02, 0.02)	
Control	0.18 (0.10, 0.26)	0.06 (0.02, 0.10)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	
p value**	0.029	0.239	0.320	0.320	0.320	

\*p value for repeated-measures ANOVA between groups.

\*\*p value for independent t-test at each time point.

This prospective randomised study assessed various parameters that are useful in determining the practical aspects of wound dressings in actual clinical settings.

## Conclusion

This prospective randomised controlled study showed that a film dressing manufactured from a deacetylated chitosan bioderivative is equivalent to hydrocolloid in terms of epithelisation, oedema, and ease of removal. The chitosan derivative film, however, produced less odour and exudate. These attributes represent attractive aspects of this new dressing.

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## Conflict of interest

The authors have no conflict of interest to declare.

## Ethical approval

The Research Ethics Committee (Human) of Universiti Sains Malaysia (FWA Reg. No. 00007718; IRB Reg. No: 00004494) and Research Ethics Committee of Universiti Kebangsaan Malaysia (JEPUKM) (No: FF-283-2012) approved this research. This study was also approved by Medical Research and Ethic Committee, Ministry of Health Malaysia (NMRR-11-948-10565).

## Authors' contributions

Funding from AS Halim, Ethics approval for USM AZ Mat Saad, JEPUKM and NMRR FM Nor. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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