THE POSSIBILITY OF USING WEFT KNITTED SPACER FABRIC AS THE WOUND DRESSING FOR PRESSURE ULCER

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Abstract- Healing of pressure ulcer wound is complicated and time consuming. Not only affecting the lives of patients and caretakers, but pressure ulcer also becomes the burden to the government. With the developing wound management techniques, companies have launched different wound dressing designed for pressure ulcer. However, regardless for their high price, it is rare that the wound dressing can provide good wound management and cushioning to the wound. Because of the excellent air permeability and compression performance of weft knitted spacer fabrics, it has been applied in different aspects including medical. This paper reports on experimental study of the requirements of pressure ulcer wound dressing and the performance of weft knitted spacer fabrics in order to verify the potential for using it as the wound dressing for pressure ulcer. Fifteen weft knitted spacer fabrics and seven wound dressings designed for burns and ulcers have been chosen from the market. The air permeability, thermal conductivity, water vapor permeability, absorbency and compression of spacers and wound dressings are evaluated. The results show that the air permeability, thermal conductivity and water vapor permeability of weft knitted spacer fabrics are comparable with the existing wound dressings. The compressional resistance and resilience of them are good for providing protection as wound dressing. The absorbency of them is somewhat better than some wound dressings, however, they are suitable for pressure ulcer wounds with no heavy extrudes.

Index Terms- Weft knitted spacer fabric, pressure ulcer, wound dressing, physical properties

I. INTRODUCTION

Pressure ulcer is the damage of skin or underlying tissue caused by prolonged pressure or pressure integrated with shear and friction over a bony prominence which heel is one of the most common sites for pressure ulcer development [1]-[5]. Although wound dressings have been in use for many years, wound management is becoming more and more complicated [6]-[7]. The aim of modern wound dressings is to improve the healing of wounds [8]-[9]. Moreover, the prevention and treatment of pressure sores need a significant amount of time and care. This not only greatly affects the lives of patients and their caretakers, but also the hospital services and costs of government as prolonged and expensive hospitalizations are required. Previous research has proven that the health costs of pressure ulcers are undoubtedly high [3], [10]-[11]. It is difficult for pressure ulcers to heal and wound dressings that provide both good absorption and a cushioning effect are rare.

Spacer fabrics is a kind of three-dimensional knitted fabrics composited of top and bottom fabric with filament yarn in between to connect them together by tuck loop stitching [1], [12]-[13]. Recently, weft knitted spacer fabric has gained great attention due to their versatile physical properties [14]. Based on the previous research, physical properties of spacer fabrics can be easily adjusted by adopting various types of spacer yarn, fabric density, thickness and fabric structure [15]-[16]. Therefore, it has been proven to have a wide area of applicability, including in medical products, due to their versatile physical, mechanical and thermal properties [17]-[18]. Their excellent ventilation and cushioning properties are also important for pressure ulcer prevention and the healing process [19].

In this study, the required physical properties of the absorbent layer of wound dressings, including air permeability, thermal conductivity, water permeability, absorbency and compression, are examined in 3-dimensional weft knitted spacer fabrics, and then evaluated and compared with those of wound dressings from the market. It aims to have a deeper understanding of the particular physical properties of weft knitted spacer fabrics tailored for use as the modern wound dressings.

II. PROCEDURE

A. Materials

Fifteen types of weft knitted spacer fabrics were purchased from local shops for use as the study samples which Samples 1 to 11 have the same structure while Samples 12 to 15 have a different structure. Therefore, the letters a and b are used to identify the two different types of structures among the fabrics.

The fabric structure, angle of spacer yarn, areal density and bulk density of them were listed in Table 1. Also, seven different types of wound dressings, Allevyn (Dressing 1), Biatine (Dressing 2), Cutinova Hydro (Dressing 3), PolyMem (Dressing 4), Duo Derm CGF (Dressing 5), Comfeel Plus (Dressing 6) and Algoplaque (Dressing 7) which are especially used for burns, ulcers and surgical wounds with cushioning effect were selected for comparison purposes. Fig. 1 and 2 are the technical diagrams of the weft knitted spacer fabrics.
The Possibility Of Using Weft Knitted Spacer Fabric As The Wound Dressing For Pressure Ulcer


Table 1. Physical properties of spacer fabrics and wound dressings (including standard deviation)

<table>
<thead>
<tr>
<th>Fabric type</th>
<th>Composition</th>
<th>Thickness (mm)</th>
<th>Spacer yarn type</th>
<th>Areal density (g/m²)</th>
<th>Bulk density (g/m³)</th>
<th>Angle of spacer yarn (B)</th>
<th>Wale</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welt_a_1</td>
<td>Weft-knitted 100% Polyester</td>
<td>1.230±0.02</td>
<td>Monofilament</td>
<td>179.465±24.3</td>
<td>146.461±8.3</td>
<td>57.37±11</td>
<td>60.47±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_2</td>
<td>Weft-knitted 94% Polyester, 6% Elastane</td>
<td>2.68±0.04</td>
<td>Monofilament</td>
<td>357.27±33.55</td>
<td>333.21±32.2</td>
<td>52.51±1</td>
<td>64.27±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_3</td>
<td>Weft-knitted 93% Polyester, 7% Elastane</td>
<td>2.95±0.06</td>
<td>Monofilament</td>
<td>420.76±46.10</td>
<td>352.09±94.91</td>
<td>75.41±1</td>
<td>75.17±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_4</td>
<td>Weft-knitted 92% Polyester, 8% Elastane</td>
<td>3.62±0.13</td>
<td>Monofilament</td>
<td>410.39±12.96</td>
<td>385.00±11.25</td>
<td>75.90±1</td>
<td>75.90±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_5</td>
<td>Weft-knitted 91% Polyester, 9% Elastane</td>
<td>2.98±0.05</td>
<td>Monofilament</td>
<td>368.11±11.07</td>
<td>323.05±13.71</td>
<td>74.56±1</td>
<td>67.31±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_6</td>
<td>Weft-knitted 91% Polyester, 9% Elastane</td>
<td>2.75±0.11</td>
<td>Monofilament</td>
<td>441.20±10.37</td>
<td>367.03±91.91</td>
<td>57.20±1</td>
<td>62.16±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_7</td>
<td>Weft-knitted 90% Polyester, 10% Elastane</td>
<td>3.36±0.12</td>
<td>Monofilament</td>
<td>460.35±11.52</td>
<td>376.03±43.40</td>
<td>40.04±1</td>
<td>52.15±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_8</td>
<td>Weft-knitted 89% Polyester, 11% Elastane</td>
<td>3.30±0.12</td>
<td>Monofilament</td>
<td>423.69±12.98</td>
<td>328.26±7.5</td>
<td>53.32±1</td>
<td>68.19±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_9</td>
<td>Weft-knitted 89% Polyester, 11% Elastane</td>
<td>2.96±0.04</td>
<td>Monofilament</td>
<td>439.19±4.28</td>
<td>376.51±44.4</td>
<td>70.69±1</td>
<td>69.46±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_10</td>
<td>Weft-knitted 88% Polyester, 12% Elastane</td>
<td>4.29±0.16</td>
<td>Monofilament</td>
<td>533.54±65.34</td>
<td>428.88±83.0</td>
<td>71.52±1</td>
<td>68.25±11</td>
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<tr>
<td>Welt_a_11</td>
<td>Weft-knitted 86% Polyester, 14% Elastane</td>
<td>3.28±0.05</td>
<td>Monofilament</td>
<td>484.31±25.3</td>
<td>474.81±60.4</td>
<td>46.70±1</td>
<td>67.49±11</td>
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</tr>
<tr>
<td>Welt_a_12</td>
<td>Weft-knitted 93% Polyester, 7% Elastane</td>
<td>2.63±0.06</td>
<td>Monofilament</td>
<td>336.44±6.00</td>
<td>292.42±31.9</td>
<td>39.63±1</td>
<td>55.52±11</td>
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<tr>
<td>Welt_a_13</td>
<td>Weft-knitted 93% Polyester, 7% Elastane</td>
<td>2.90±0.09</td>
<td>Monofilament</td>
<td>437.03±16.5</td>
<td>370.03±16.1</td>
<td>80.19±1</td>
<td>71.84±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_14</td>
<td>Weft-knitted 89% Polyester, 13% Elastane</td>
<td>2.88±0.04</td>
<td>Monofilament</td>
<td>439.37±23.7</td>
<td>458.41±31.7</td>
<td>76.59±1</td>
<td>81.13±11</td>
<td></td>
</tr>
<tr>
<td>Welt_a_15</td>
<td>Weft-knitted 87% Polyester, 15% Elastane</td>
<td>2.91±0.06</td>
<td>Monofilament</td>
<td>59.09±21.31</td>
<td>184.35±13.8</td>
<td>78.65±1</td>
<td>77.23±11</td>
<td></td>
</tr>
<tr>
<td>Dressing 1 (Allevyn)</td>
<td>Hydrocellulose polyurethane foam</td>
<td>6.04±0.06</td>
<td>-</td>
<td>721.23±20.9</td>
<td>119.32±48.8</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dressing 2 (Biatain)</td>
<td>Polyurethane foam</td>
<td>4.52±0.06</td>
<td>-</td>
<td>754.50±97.5</td>
<td>157.94±15</td>
<td>-</td>
<td>-</td>
<td></td>
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<tr>
<td>Dressing 3 (Cutinova Hydro)</td>
<td>Hydro-cellulose polyurethane matrix</td>
<td>1.56±0.03</td>
<td>-</td>
<td>1823.96±17.8</td>
<td>113.7±49.1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dressing 4 (PolyMem)</td>
<td>Polyurethane polyurethane matrix</td>
<td>4.62±0.02</td>
<td>-</td>
<td>946.14±27.1</td>
<td>212.23±21.6</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dressing 5 (Duo Derm CGF)</td>
<td>Hydrocolloid</td>
<td>2.34±0.19</td>
<td>-</td>
<td>1344.80±25.7</td>
<td>614.21±26.7</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dressing 6 (Cloenta Plus)</td>
<td>Hydrocolloid</td>
<td>1.94±0.03</td>
<td>-</td>
<td>1043.09±4.4</td>
<td>1080.14±87.2</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Dressing 7 (Alloplaque)</td>
<td>Hydrocolloid</td>
<td>0.96±0.03</td>
<td>-</td>
<td>1320.09±20.26</td>
<td>957.09±14.8</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Allevyn and Biatain are non-adhesive dressings which former contains an absorbent hydrocellular pad sandwiched between a perforated non-adherent wound contact layer and a waterproof outer film while latter is polyurethane foam dressing providing a good healing environment for moist wounds and effective exudate management for fragile skin especially pressure ulcers. Cutinova Hydro contains a highly absorbent material embedded in a self-adherent polyurethane matrix for the management of extruding wounds surrounded by intact skin. [20]. PolyMem is a non adhesive wound dressing composed of a hydrophilic polyurethane membrane matrix. According to the product description, the product is optimized for oxygen and moisture vapor permeability and acts as a barrier to liquid. Duo Derm CGF, where CGF stands for control gel formula, has hydrocolloids within the dressing while the adhesive layer contains polymers which will form cohesive gel when it comes into contact with wound exudates [20]. Comfeel Plus Ulcer Dressing can be used for low to moderately exuding leg and pressure ulcers. When it absorbs exudates, it will form a whitish gel. Finally, Alloplaque is a kind of adhesive hydrocolloid dressing used for pressure ulcers and other moderately exuding wounds. It is composed of carboxymethylcellulose particles in an elastomer network. When it comes into contact with exudate, it will form a soft moist gel that can enhance the wound healing process.

All of the tests were conducted in accordance with ASTM 1776, at a temperature of 20°C and relative humidity of 65% and all of the test samples were also conditioned at 20°C and relative humidity of 65% for 24 hours before the experiments were conducted.

B. Air permeability

The KES-F8-API air permeability tester was adopted to evaluate the air resistance of the fabrics to the passage of air which is strongly related to comfort. The speed of the piston was 2 cm/s and the air flow rate was 8 π cm³/s. As weft knitted spacer fabrics have many pores on their surface, the smallest hole of 0.2 π cm² was selected for more precise measurements, and the air flow rate per unit area was 0.4 π m/s. On the other hand, as the structures of dressings are denser, the largest hole of 20 π, with an air flow per unit area of 40 π m/s, was selected. For each sample, 10 readings were taken, and the average value of the air resistance (R) was measured as kPa · s/m.

C. Thermal conductivity

The KES-F Thermo Labo II was used to measure the ability of the fabric to conduct heat. Ten specimens were measured for each case and the average value was recorded. The amount of heat that passes through the sample from the power consumption of the test plate heater was measured and the thermal conductivity value (k) recorded as a unit of W/mK and the KSI, the SI unit of k, can be calculated by using the following equation:

\[
\text{Thermal conductivity (k)} = \frac{\text{Heat flow rate \times distance}}{\text{area \times temperature difference}} = \frac{W}{t \times D \times A \times \Delta T}
\]
D. Water vapor permeability

The cup method of BS 7209 was adopted to evaluate the water vapor permeability (WVP) of the samples to demonstrate the transmission of moisture or vapor from the skin. In each case, 10 specimens were measured and the average value was recorded.

By measuring the weight of the samples before the experiment and after 24 hours, the WVP was calculated by using the following equations.

\[ WVP(\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}) = \frac{24M}{At} \quad (2) \]

\[ A = \frac{\pi d^2}{4} \times 10^{-6} \quad (3) \]

where \( W \) = loss in mass (g), \( t \) = time between weighing (hr), \( A \) = internal area of cup (m²) and \( d \) = internal diameter of cup (mm).

E. Absorbtion

The absorbtion of the samples was evaluated in accordance with BS 7959-1:2004. Both distilled water and 0.9% saline water were selected as the testing liquids and their temperature was controlled at 20 ± 2°C. In each sample, 5 specimens were measured and the average value was recorded.

The weights of the samples were measured before and after the experiment, their sorbency after 30 s of draining was calculated by using the following equations.

\[ S_{30}(\text{L/kg}) = \frac{V_{30}}{W_{30}} \quad (4) \]

where \( W \) = mass of the test sample (kg), \( V \) = volume of liquid (L) held by the test sample after 30 s of draining.

\[ V_{30} = \frac{W_{30}}{P} \quad (5) \]

where \( W_{30} \) = mass of liquid held by the test sample after 30 s of draining (kg).

\[ W_{30} = W_{A2} - W_{A1} - W_{p} \quad (6) \]

where \( W_{A1} \) = mass of the receptacle + “S” hook (kg), \( W_{A2} \) = mass of the receptacle + “S” hook + test sample+ liquid retained after 30 s of draining (kg), and \( P \) = density of the test liquid (kg/L).

F. Compression

KES-FB3-A was adopted to evaluate the compression property of spacer fabrics. The sample size of the fabric used in the compression test was 10 cm × 10 cm and the maximum pressure used was 200 gf/cm². For each sample, 9 specimens were tested and the average values were reported.

III. RESULTS AND DISCUSSION

G. Air permeability

The results of air resistance (R) of all the spacer fabrics and wound dressings were shown in Fig. 3. A higher value of R indicates poor air permeability of the samples. Fabric density, thickness and tightness are regarded as the key influencing factors of the air permeability of fabrics [16].

Based on the results, no data were recorded for all Dressings even when the largest hole and the maximum range were used as their air resistance exceeded 500 kPa·s/m. The results proved that wound dressings have very poor air permeability. Dressing 1 is the thickest among all of the test samples while other Dressings 3, 5, 6 and 7 have larger bulk density and Dressings 3, 5, 6 and 7 even have an adhesive layer. Therefore, air is not easy to pass through them and poor air permeability will result.

Weft_a_1 have better air permeability than other weft knitted spacer fabrics as its thickness is relatively smaller than others. As the bulk density of weft_b_15 is the greatest among all weft knitted spacer fabrics, its air permeability is the poorest one. Although weft knitted spacer have two different structures, only the interlaying structures of them are different while both face and back of them are plain knitted fabrics. Therefore, the pores on their fabric are similar. The variation of the air permeability of them is because of thickness, bulk density and the angle of spacer yarn.

Air permeability is one of the key basic requirements of an ideal wound dressing which can provide a ventilated environment for wounds. Based on the above results, the air permeability of the weft knitted spacer fabrics always have better air permeability than existing wound dressings.

H. Thermal conductivity

The results of thermal conductivity of all samples were shown in Fig. 4. A higher thermal conductivity values indicates that the sample can conduct heat away from skin and body faster [16], [21]-[22]. Previous research proved that thermal conductivity of individual fibers, fabric thickness, bulk density and type and angle of spacer yarn are the most influencing factors of the thermal conductivity of samples [16], [23]-[24]. In this study, all of the spacer fabrics are made of polyester, therefore, the differences in thermal conductivity are due to their
thickness, bulk density and angle of spacer yarn. The results showed that increase the thermal conductivity of spacer fabrics with increasing fabric thickness, density and angle of spacer yarn as there are less spacer to trap air inside or enhance the ventilation of heat. Weft_a_10 has higher thermal conductivity and followed by Weft_a_7, Weft_a_8 and Weft_a_11 as they have larger thickness among weft knitted spacer fabrics. Based on the results obtained, the thermal conductivities of the spacer fabrics are similar to one another, but lower than those of the dressings, especially Dressings 3, 6 and 7 because those Dressings have extremely high bulk density than others.

Thermal conductivity is critical for an ideal wound dressing as it help to can enhance good thermal regulation of the wound environment and reduce the accumulation of heat building up. Based on the above results, spacer fabrics are comparable with most of the existing wound dressings.

I. Water vapor permeability

In order to evaluate the penetration of water vapor from skin to outside through the test sample, water vapor permeability is adopted and the results are shown in Fig. 5. Higher WVP value indicates that more water vapor can pass through the sample to outside. Previous study proved that WVP performance is highly correlated with bulk density, thickness and fabric structure [21]. Based on the results, the WVP of spacer fabrics is always better than those wound dressing indicating that more water vapor can penetrate through the spacer fabrics as the pores on the spacer fabrics facilitates the penetration of water vapor. Weft knitted spacer with structure “b” has better WVP than most of the spacers with structure “a”. Also, WVP decreases with increasing bulk density and thickness as more water will be trapped inside. On the other hand, with the smallest bulk density among Dressings, Dressings 1 and 2 have relatively large WVP which facilitates water vapor to penetrate through it. The rest of Dressings have extremely small value of WVP, apart from their larger bulk density, having an adhesive layer will hinder the penetration of water vapor.

WVP is regarded as one of the basic criteria of wound dressings as it can maintain ventilation of wound by transmission of wound exudates and sweat from surrounding area. The results show that the average WVP of the spacer fabrics is comparable or even better than that of the wound dressings.

J. Absorbency

The results of absorbency test of water and 0.9% saline water are shown in Fig. 6 which a higher absorbency value means that more water can be absorbed. Both spacers and dressings have poor absorbency ability in 0.9 saline solution rather than water as the NaCl particles in 0.9% saline water is larger than that of H2O particles. In the beginning of absorption, due to the presence of the concentration gradients between solution and samples, small water particles will enter the sample. However, when a hypertonic solution is formed, the water vapor particles cannot further enter the samples but start to move out from sample to the solution. Therefore, the absorbency ability of all specimens in 0.9% saline solution is poor than that of pure distillated water.

According to the results, Dressing 1 which made of a highly absorbent material (hydrocellular polyurethane) has the best absorption ability among all samples as it can absorb the fluid can be directly into themselves rather than into the space between the fibers. Dressing 2 is made of polyurethane foam too. However, its thickness is smaller than Dressing 1, there is fewer space inside it which makes its absorbency is poorer than Dressing 1. Dressing 4 has good absorbency ability as it is made of a thick layer of absorbent materials, hydrophilic polyurethane matrix. Although Dressings 3, 5, 6 and 7 are also made of absorbent materials, which are hydrocolloid and hydro-active polyurethane matrix, they have poor absorbency in this study. This is because the surface of them have an adhesive layer which may greatly reduce its absorbency as the film prevents the dressing from absorbing wound extrudates. For spacer fabrics, their absorbency is similar as they are made of polyester fibres which have poor water absorbency. The differences between them are due to their bulk density and thickness.
Fig. 6 Absorbency of spacers and wound dressings tested by using water and 0.9% saline solution.

Absorbency is one of the most critical requirements of wound dressings as different wounds may have different degree of exudates. Also, the absorbency performance will influence the number of times that the wound dressing will need to be changed. Based on the results, the absorption ability of spacers is better than that of dressings with an adhesive layer, that are, Dressings 3, 5, 6 and 7. Although spacer fabrics used in this study are made of polyester which their absorbency is poorer than those wound dressings made of highly absorbent materials, the wicking property of them can help to draw extrudes from wound through fabrics to outside rather than trapping inside the wound dressings in order to inhibit the possibility of bacteria growth.

K. Compression

Previous literature proved that pressure greater than 32 mmHg (around 4.27kPa) is generally considered as the breakdown pressure which exceeds the capillary closing pressure in healthy individuals [25]-[26]. Also, based on the heel interface pressure measured before, the means of heel interface pressure of elderly when they are at 60 degrees and 90 degrees to the standard mattress are 50.15mmHg and 78.71mmHg respectively. Also, the maximum heel interface pressure of them on standard mattress at 90 degrees is 108.75mmHg [1]. Therefore, in this study, the compression behavior of spacer fabrics at 4.27kPa (32mmHg), 6.69kPa (50.15mmHg), 10.47kPa (78.71mmHg) and 14.50kPa (108.75mmHg) will be given more focus. The compression stress-strain and compression stress-thickness curves of all the spacer fabrics are shown in Fig. 7 and 8.

The results show that the compression resistance increase with increasing angles of spacer yarns in the course-wise direction which has also been proven by previous research [4]. Besides, the results also indicate that the percentage of polyester have influence on compression resistance. The results show that Weft_a_1, Weft_a_2, Weft_a_3 and Weft_b_12, which have highest percentage of polyester content, have the poorest compression resistance. Other weft knitted spacer fabrics also follow this trend. Although Weft_a_11 has the lowest percentage of polyester, its compression resistance is not the best one among weft knitted spacer fabrics. This is because its spacer yarn angle in course-wise direction is not large. Therefore, apart from composition percentage, spacer yarn angle in course-wise direction is also a critical factor. Although Weft_a_8 and Weft_a_10 do not have the lowest polyester percentage and their spacer yarn angles are not the largest, their compression resistance is good. This is because their fabric thickness is relatively large when comparing with others, which greatly enhance their compression resistance. This is also true for Weft_a_8, Weft_a_9 and Weft_b_14 which have the same polyester content (89%). The spacer yarn angle of Weft_a_8 and Weft_a_9 is not as large as Weft_b_14, however, their thickness is relatively larger. Weft_a_3, Weft_a_4, Weft_b_12 and Weft_b_13 are made of same percentage of polyester (93%) but with different interlacing structure. It is obvious that Weft_a_4 has the best compression resistance among four while the rest of them are similar. This is because the spacer yarn angle in course-wise direction of Weft_a_4 is the largest while that of Weft_b_12 is the smallest. Therefore, the compression resistance of Weft_b_12 is the poorest.

It is obvious that weft knitted spacer fabrics always have better compression resistance than existing wound dressings at different pressure levels. Also, the resilience of these weft knitted spacer fabrics are good as the area between two curves of it is small. This is also true for Dressings 3, 6 and 7. On the other hand, Dressings 1, 2, 4 and 5 have large area between curves which indicate their compression resilience is poor. Dressings 1 and 2 have similar compressional curves as both of them are polyurethane foam with similar thickness and bulk density. Dressing 1 has the best compression resistance among all when pressure is under 2kPa. However, its compression strain increases rapidly when gradually increasing the pressure which means its sponge layer cannot absorb much pressure. This is also true for Dressing 2 which has similar compression resistance like weft knitted spacer fabrics when pressure is under 2kPa. Although Dressings 3 and 4 are also made of Polyurethane matrix, the bulk density of Dressing 3 is 5.5 times higher than that of Dressing 4 which makes it stiffer to withstand pressure. Fig. 8 shows the change in fabric thickness under compression stress. It can be observed that there is only a small thickness change in weft knitted spacer fabrics. This means weft knitted spacer is not easily compressed even under a pressure of 14.50kPa due to the present of the spacer yarn between the fabrics. On the other hand, Dressing 1 has the largest change in thickness when compared to the others. Its thickness decreases around 3.5 mm under a force of 14.50kPa because Dressing 1 has a foam structure which is not stiff. This is also true for Dressing 2 and 4. On the other hand, the decrease in the thickness of Dressing 5 is not obvious as it is a very stiff material and
cannot be easily compressed. For Dressing 5, there is a turning point at nearly 6kPa as its two different layers have different compression properties. Although Dressing 6 and 7 are also made of Hydrocolloid like Dressing 5, their thicknesses are the smallest among all dressings and they have large bulk density like Dressing 3 which makes them stiffer to resist pressure.

As 4.27kPa is regarded as the reference for the breakdown pressure of capillary, the compression resistance results prove that the weft knitted spacer fabrics have better performance to resist pressure and maintain their thickness. From the results of heel interface pressure conducted, 6.69kPa and 10.47kPa are the averages of heel interface pressure for those using standard hospital mattresses when their heels are at 60 degrees and 90 degrees to the mattresses respectively. Also, 14.50kPa is the maximum average pressure for those heels at 90 degrees on standard mattress. As 60 degrees and 90 degrees at the common natural heel postures of elderly, the relief of heel interface pressure at these postures is important.

From the compression results, it proves that weft knitted spacer fabrics have better compression resistance and resilience than those pressure ulcer wound dressings. Therefore, weft knitted spacer fabrics can provide a good cushioning effect to protect wounds against mechanical collision.

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The Possibility Of Using Weft Knitted Spacer Fabric As The Wound Dressing For Pressure Ulcer

**CONCLUSION**

The critical and necessary requirements of wound dressings for pressure ulcer are considered. Being a good wound dressing for pressure ulcer, not only breathability, thermal regulation and cushioning properties. Therefore, in this study, the air permeability, thermal conductivity, water vapor permeability, absorbency and compression of weft knitted spacer fabrics are investigated and compared with existing wound dressings in order to evaluate whether the former can be used as a substitute for the latter.

Based on the results, it proves that both air permeability and water vapor permeability of spacer fabrics are much better than that of wound dressings due to their structure. Although the thermal conductivity of spacer fabrics is not as good as all dressings, they are still comparable with Dressings 1, 2, 4 and 5. This is also true for the absorbency performance. Their absorbency property is comparable with Dressings 3, 5, 6 and 7. The results also prove that both compression resistance and compression resilience of some weft knitted spacer fabrics are better than that of wound dressings.


