Pressure Exerted By Head Garment Used In Pressure Therapy Treatment For Facial Burn Injury

[1]A.F Aiman, M.N Salleh[2], K.A Ismail[1]
[1]School of Manufacturing Engineering, Universiti Malaysia Perlis, Malaysia
[2]School of Technology Management and Logistic, Universiti Utara Malaysia, Malaysia
aiman@unimap.edu.my, najib@uum.edu.my, k.azwan@unimap.edu.my

***Abstract*— Head garment was used as one of methods in managing hypertrophic scar treatments. The application of the head garment produced pressure which increase healing process. Although there are many types of head garments were produced, limited studies reported the amount of pressure generated from its application. The objective of this study is to measure the pressure exerted by full face head garment produced by Occupational Therapist (OT) from local hospital. A pressure measurement system was developed using Flexiforce pressure sensor combined with Arduino microcontroller board. Sensor was placed underneath the garment at different locations. Results from the experiment indicates pressure outputs of 0mmHg to 48mmHg. The experiment also discovered that the area near nasal and eyes does not produced any pressure.**

***Index Term*— Head garment, burn injury, hypertrophic scar, pressure, sensor**

I. INTRODUCTION

Burn injury victims suffered from many types of injuries and one of them is hypertrophic scar. The scars at facial area affected the appearance and confidence levels of the patient. There are several methods in managing the hypertrophic scars as reported by previous studies. One of non-surgical methods that still being practiced is pressure garment [1, 2]. The problems occur regarding head segment is the complex surface areas which consist of different radius of curvature derived from the concave and convex areas of the human body [3].

The exact mechanism of how pressure positively influenced the maturation of hypertrophic scars are not fully understood [4]. However, possible mechanism of pressure therapy treatment suggested that by increasing the collagen lysis and slowing protein synthesis will increase healing process of the scar [5, 6]. Regarding pressure therapy treatment, pressure garment should be applied to the patient`s wounded area for a long time and only removed for hygiene purposes. Most researchers agreed that best pressure exerted from the pressure garment is within the range of 15mmHg to 24mmHg or 1999.85Pa to 3199.74Pa [4, 7, 8]. Pressure more than 40mmHg may result to other complications [1]. On the other hand, most of the pressure was measured by OT only using rule of thumb based on patient`s feedbacks of the pressure exerted by the garments or assessed using ‘‘sight, touch and experience” [6, 9]. Several studies reported the results of applying the Silon Mask and the transparent face mask. However, there are no quantitative results reported [10–12]. Currently, there are no studies reported on the measurement of pressure generated by the full face head garment up to the author`s knowledge. Hence, the objective of this study is to measure the pressure generated from the application of the head garment using a pressure measurement system developed from Flexiforce pressure sensor and Arduino microcontroller board.

II. METHODOLOGY

This study intends to measure pressure exerted by head garment which was generally used in managing hypertrophic scar treatment [6]. In this case, the targeted wounded area is in the facial area. A measurement system was developed using a Flexiforce from Tekscan, USA. A low force sensor A201 1lb selected due to the range of the pressure output, which is between 15mmHg to 40mmhg. The sensor was placed under the head garment on a subject in static condition. Pressure outputs are monitored and recorded for data analysis. The outputs of the readings was recorded until the readings stabilized, which takes about 5 minutes at each location.

a)Fabrication of the Head Garment

A full face type head garment was selected for this study. The head garment fabricated by OT from local hospital. The garment was made for a normal human without any burn injuries at facial area. Figure 1 shows the process flow for the head garment fabrication. As for the reduction factor, most of head garment fabricated by OT in local hospital used a single reduction factor. In order to determine reduction factor, they marked a finished garment with 2 points with a dimension of 16mm in length at any location of the head garment. Then, after fitting the garment, length of the two points measured again. If the points stretched to 20mm in length, the reduction factor determined at 0.2 or 20%. If the dimension is shorter or exceed 20mm, adjustments were made until it reaches 20% of the reduction factor.

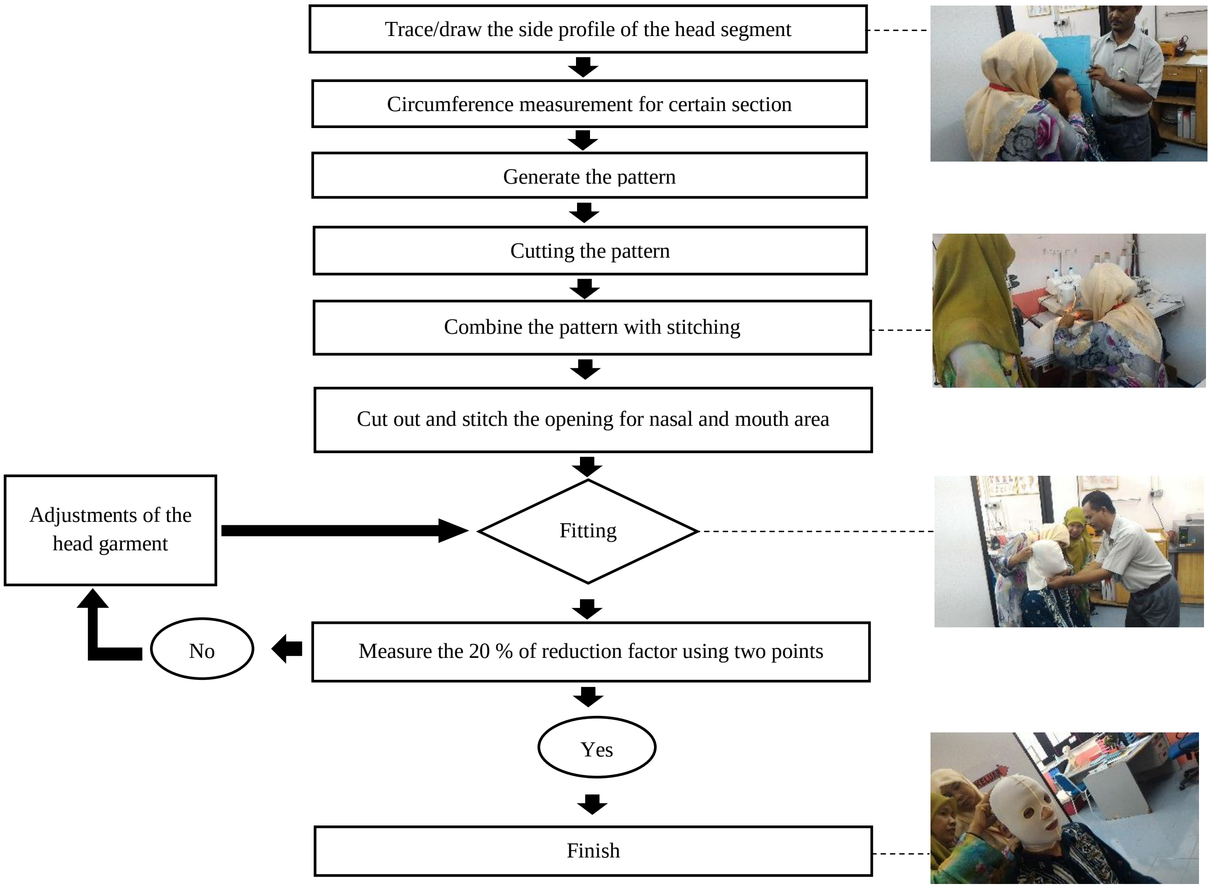
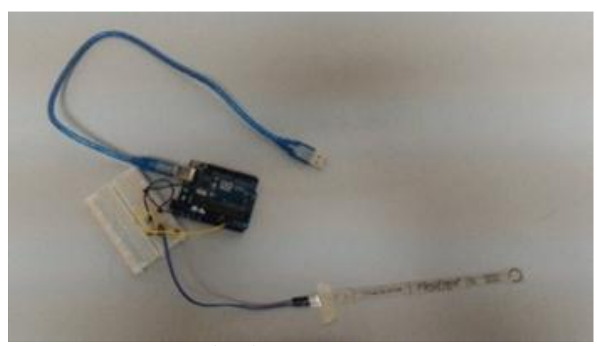


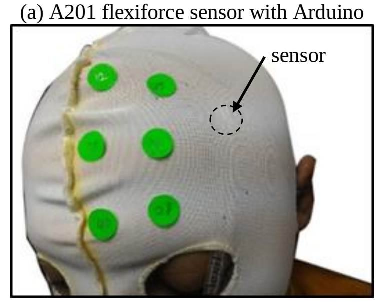
Fig. 1. Process flow of head garment fabrication

b)Pressure Measurement System

Pressure measurement system was developed using a Flexiforce sensor from Tekscan, USA. The sensor proven in measuring pressure outputs from pressure garments previoulsy [13–16]. Arduino microcontroller board combined with the sensor for the data acquisition. Standard weights ranging from 10g to 50g used for the calibration in order to determine the linearity of the sensor output. Regarding the normal practiced by the OT in measuring the pressure, the output converted to millimeter of mercury (mmHg) units from the calibration results. Figure 2(a) shows the pressure measurement system and (b) pressure sensor placed under HG for the experiment.



(a) A201 flexiforce sensor with Arduino



(b) Sensor placed under the head garment

Fig. 2. Measuring the pressure generated from the head garment

c)Measuring the Pressure Exerted By the Head Garment

Regarding pressure measurement, sensor was placed beneath head garment. Each measurement was recorded when the reading is stabilized which takes around 5 minutes for each location. The locations of the sensor are shown in figure 3. The locations labelled as A to V and the mirror location labelled as A` to V`. Five measurements were taken and the average value was used to plot a graph. All measurements done in static condition with no movements from the subject during the process.

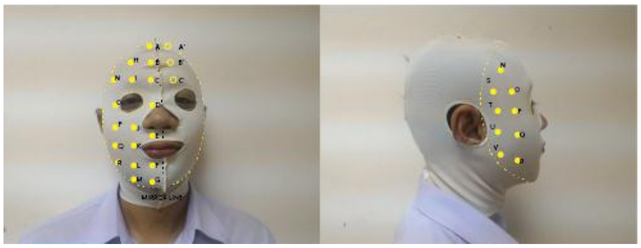


Fig. 3. Sensor locations for measurement

III. RESULTS AND DISCUSSION

a)Sensor Calibration

Pressure sensor output readings were measured three times for each 10g to 50g weight. Table 1 shows the coefficient of variation (CV) for pressure sensor. The amount of the weight was selected due to the maximum pressure output calculated based on the formula of pressure equal to force over area. The weight in Newton (0.49N) divides by the sensor active area, 0.000713m^2 produced pressure of 6877.03Pa or 51.58mmHg. The CV of measured voltage with 0g weight is the maximum, caused by probability of the small amplitude of output voltage that is easily affected by the measured error and voltage drift [15]. Mean value of pressure outputs was used to plot the graph shown in figure 4. Then, another graph which converted the pressure outputs in mmHg shown in figure 5. The equation from the linear graph then uploaded to the Arduino programming for the pressure measurement procedures.

Table I
Coefficient of variant (CV) of the pressure sensor voltage output

Load (g)	Sensor output reading (V) Value 1	Value 2	Value 3	SD	Mean	CV
0	0.00	0.01	0.00	0.01	0.00	1.73
10	0.92	0.90	0.91	0.01	0.91	1.10
20	1.85	1.84	1.83	0.01	1.84	0.54
30	2.21	2.22	2.21	0.01	2.21	0.26
40	2.63	2.60	2.61	0.02	2.61	0.58
50	3.37	3.38	3.38	0.01	3.38	0.17

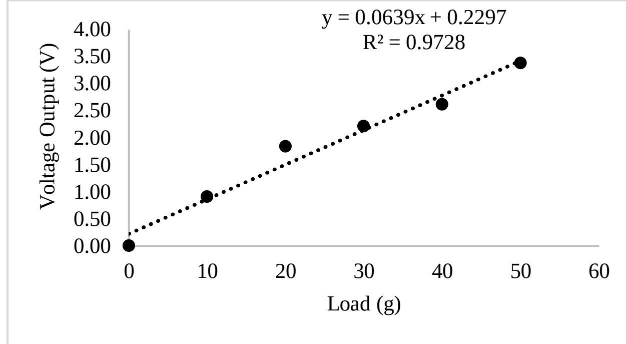


Fig. 4. Calibration of the pressure sensor

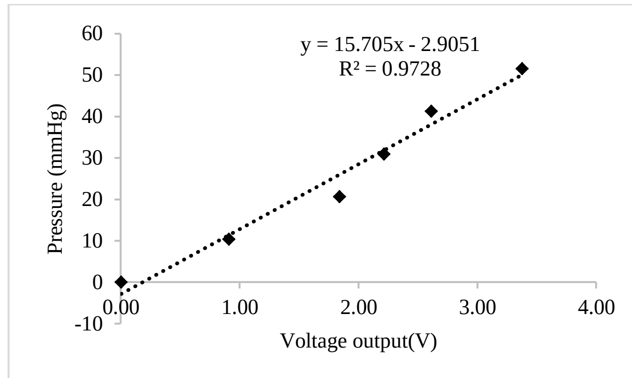


Fig. 5. Linear equation for the pressure output in mmHg

b)Pressure Exerted By the Head Garment

Figure 6 shows results of pressure generated at all sensor locations in the experiment. The average value from the measurements was used to plot the graph.

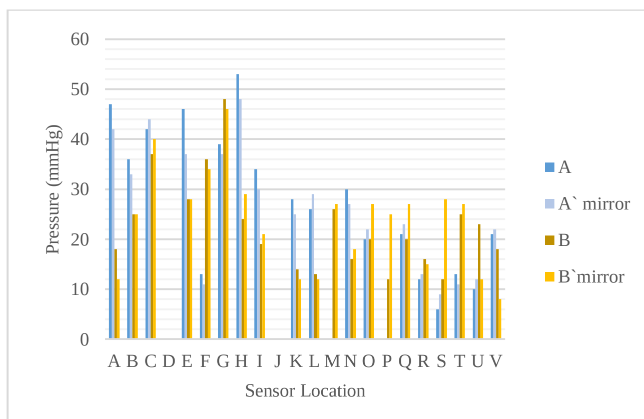


Fig. 6. Pressure outputs at facial area

Based on figure 6, pressure generated through the application the head garment ranging from 0mmHg to 48mmHg. The graph indicates some areas produce low and high pressure exceeding 40mmHg.

Although fabrication process of the head garment used a single reduction factor, pressure outputs vary at difference areas. This is due to the variations of radius of curvature values at each location. According to Laplace`s Law, pressure is equal to the radius of curvature determine from the circumference dimension. However, it can only be useful at lower limb or upper limb parts which tend to have a more cylindrical shape compared to facial area [8]. Therefore, this study shows that the circumference for facial area can only be referred as an assumption because of each vertical section-cut of the head segment consists of different radius of curvature and tangent connectivity. Facial area has more concave and convex surfaces that contribute to the different values of pressure outputs. Another factor that influence the pressure outputs is tissue elasticity which is differences between each human.

c) Zero Pressure Exerted Area by the Head Garment

According to the results, there are some areas which does not produce any pressure due to the non-contact of the head garment with surface of the facial area. Figure 7 shows coloured area which produced no pressure exerted by the head garment.

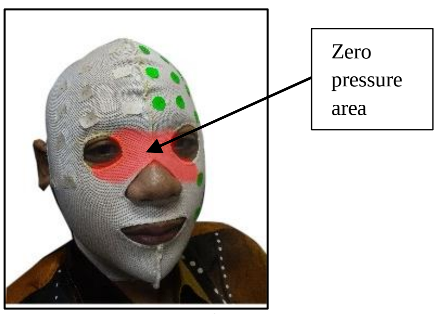


Fig. 7. Zero pressure area produced from head garment

In order to increase pressure at this area, improvement that can be done is by inserting a padding to increase the pressure by placing the padding underneath the head garment. As for future development, the padding can be designed by using Computer Aided Design(CAD) software and produced by additive manufacturing technology with appropriate materials that can ensure optimum fitting with the contour of the patient`s facial area.

IV. CONCLUSION

Referring to pressure measurement results, it shows that the fabrication method of the head garment produce an adequate pressure for the treatment. However the process takes mostly up to four (4) hours to finish a single head garment. Despite the fabrication process used a single reduction factor, the pressure outputs manage to produce pressure outputs mostly within the pressure range and only two locations near the chin area which exceed the maximum of 40 mmHg of pressure output. Nevertheless, the head garment gone through some adjustments in order to get the 20% of the reduction factor. The results of the experiment may behave differently with another different subject due to differences of tissue elasticity and radius of curvature for each human. Therefore, for future development, consideration of the reduction factor will be improved to produce a head garment to obtain optimum reduction factor. 3D data acquisition for the head segment using 3D scanning apparatus will be used to attain more details circumferences dimension. A computer generated pattern for the head garment with a combination of predicted reduction factor to achieve more optimum pressure should be developed to decrease the time consuming in head garment fabrication.

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