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The Assessment of Pocket Mask Fit Among Malaysian Citizen

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Abstract: During this Covid-19 pandemic, a pocket mask is a crucial medical device that is used as a medium to perform cardiopulmonary resuscitation. One of the most important factors on determine the oxygen efficiency delivered is the proper fit of the devices themselves. To test the fit. 2 models are required to be tested which is the pocket mask and a face model. This research is purposely to investigate the 3D anthropometry data and also gaps between the devices and human face by applying the analytical approach of 3D scanning and software gap analysis. Because this research measures a high number of participants, the research become more accurate and precise. The result shows that the pocket mask surfaces mostly covered the front face only a little gap occurs and that gap can be overcome by applying the correct technique provided by the Malaysian Ministry of Health. The result obtained can be used as a reference to create a much better respirator in the future, this technique in this research also can be used as an example for future researchers to calculate any fit in any wearable devices.

Keywords: 3D Anthropometry, Pocket Mask, Gap Analysis

1. Introduction

A pocket mask is known as a cardio pulmonary resuscitation mask is a half-mask respirator that widely used by the rescuer to deliver oxygen during cardiac arrest. Previous research shows that a pocket mask is the most cost-effective and convenient emergency medical device to use compared to the other half-mask respirator which is a bag valve mask[1]. The fit of the mask is very important to ensure comfort for the victim. It is also important to make sure oxygen can be effectively delivered to the victim during cardiopulmonary resuscitation (CPR). The fit of the mask is evaluated by comparing the facial anthrophonic data with the dimension of the pocket mask. Facial measurements data are already been collected in the past research and they have been applied for an ergonomic design of a half-face mask such as the pocket mask.

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The pocket mask is mostly made by a fixed dimension that follows the facial data of non-Malaysian citizens. This problem can cause a lack of oxygen transfer by the cardiopulmonary resuscitation process using the pocket mask. So, a pocket mask fit assessment must be conduct to evaluate the fit of the pocket mask among Malaysian citizen

Many previous study suggested that some facial dimensions can be related to the respirator fit. They propose that face dimensions such as face length, face width, nose length, and lip width can be used to evaluate the mask fit However, the identified facial dimensions were different in each study. For example, (S.F. Gross & Horstman, 1990) show that lips width is as important and applicable to the respirator design [2]

Anthropometry measurement is very important to develop protective equipment which provides a line of defence to a worker who works on a high-risk condition [3]. In the past study, there is no exact study regarding the pocket mask. But we can refer to its close type which is the half-face respirator or to be exact the air-force oxygen mask. A pocket mask can be classified as a half-face respirator to its design that covers the nose and mouth area. Different from the other mask which is the full-face mask which covers the entire face. So, in this study, 10 participants will be used to investigate their facial data and also its effect on the gap between pocket masks. This study is conducted in purpose to help a future researcher to understand the importance of this aspect.

2. Materials and Methods

Overall, the step determines the facial anthropometry data and the gap analysis s consisted of several steps: (1) finding Malaysian participant, (2) pocket mask is been scanned using high end fixed scanner, (3) while the participant was scanned using a portable scanner with wearing the pocket mask and also not, (4) the 3 meshes are then been aligned in a Geomagic Studio 2012, (5) several analyses are apply on the align meshes to solved our objectives.

2.1 Materials

3 scan data are required which includes the participant head, pocket mask and the mesh of the participant wearing the pocket mask. The scan data are acquired by using either a fixed scanner or a portable scanner.

Before we get the scan data. It is crucial to find participants that willing their faces to be scanned. There is 10 participant that willing to involved in this research. They are a student at University Tun Hussein Onn Malaysia. The participant is aged between 20 to 25.

Table-1: Detail of Participant Involved

No	Participant	Age	Residence	Ethnic
1	A	20	Parit Raja	Malay
2	B	20	Parit Raja	Malay
3	C	24	Parit Raja	Malay
4	D	20	Parit Raja	Malay
5	E	20	Parit Raja	Malay
6	F	25	Parit Raja	Iban
7	G	20	Parit Raja	Malay
8	H	21	Parit Raja	Malay
9	I	23	Parit Raja	Malay
10	J	23	Parit Raja	Malay

2.2 Methods

3D system sense 2 scanner is used to scan the material. The mesh produces by the portable scanner will be transferred to Geomagic 2012. The editing and repairing process must be done to clean the surface of scanned data so that the analysis will be exact without too much error. During the scanning process, participants were asked to sit straight and look at a fixed point on the wall with his/her usual facial expressions [4]. Participants are required to wear the swimming cap to reduce the hair irregulates that can affect the scan meshes. The mesh has then been clean up using various features in Geomagic 2012, Figure 1 shows that participant head scan data that have been cleaned up. And figure 2 shows the pocket mask scan that has been scan using an advanced fixed 3D scanner

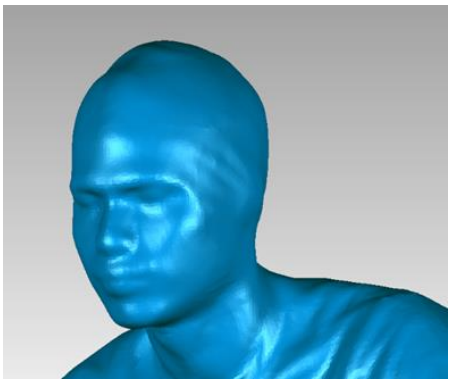


Figure 1: Clean Participant Scan

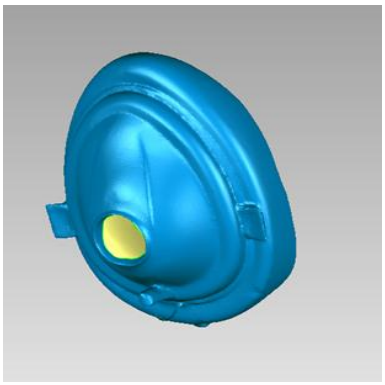


Figure 2: Clean Pocket Mask Scan

. The pocket mask shows a high level of scan accuracy and quality after been scanned using the advanced fixed 3D scanner. During that scan, the pocket mask was spray using grey powder paint to make sure that the transparency of the pocket mask is been covered for a proper scan. Both of the scans are been repaired using a feature such as (a) remove the spike, (b) fill single, (c) fillet reconstruct and (d) mesh smoothing.

2.3 Scan Alignment

The alignment of the mesh is a process of combining all mesh into one mesh. This process involves the alignment of 3 scan data that have just been clean. In this case, there are 2 stages on aligning the 3-mesh data. By referring to figure 3,, (i) the participant head will be aligned first with the mesh of the participant wearing the pocket mask and this is known as the first stage of alignment. After that, the 2

align mesh are then grouped. During the second stage, (ii)the group mesh of the participant's head is then aligned with the pocket mask by referring to the shape of the 1st alignment as shown in figure 4.

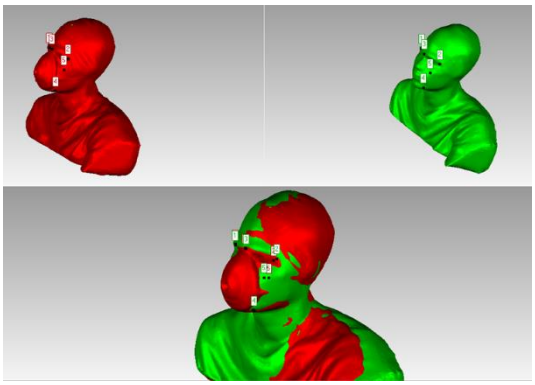


Figure 3: First Alignment Process

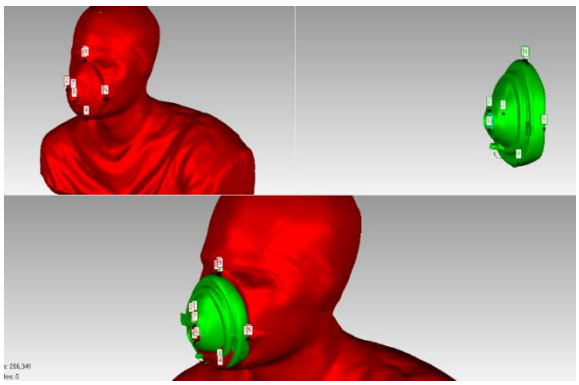


Figure 4: Second alignment process

After that, the mesh of the participant wearing the pocket mask is removed thus its only act as a reference. A complete data of mesh is presented and it had been aligned correctly and ready to step into the next process. The pocket mask can be analysed in terms of its gap and facial anthropometry data. Figure 5 show the complete aligned mesh.

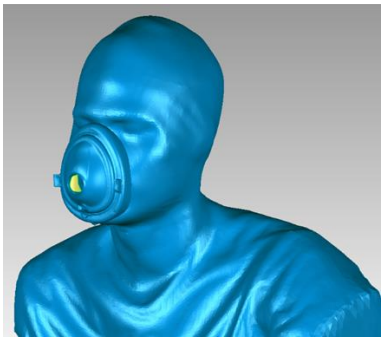
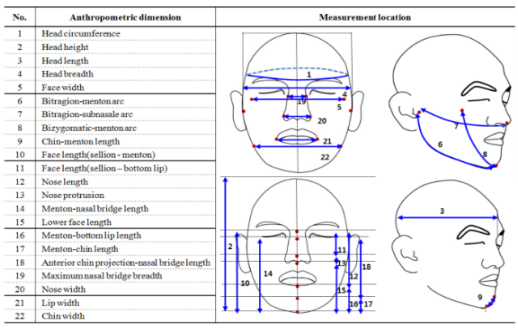


Figure 5: Final Aligned Mesh

2.3 Facial Anthropometric Measurement

Anthropometry is an art and science used extensively for measuring the soft tissue proportions [5] In terms of pocket masks we will measure some of the facial dimensions with the front face that covers the area of the pocket mask The dimension is been referred to from the dimension by Jeong Rim Jeong [6]



No.	Anthropometric dimension
1	Head circumference
2	Head height
3	Head length
4	Head breadth
5	Face width
6	Bitragion-menton arc
7	Bitragion-subnasale arc
8	Bizygomatic-menton arc
9	Chin-menton length
10	Face length(sellion - menton)
11	Face length(sellion – bottom lip)
12	Nose length
13	Nose protrusion
14	Menton-nasal bridge length
15	Lower face length
16	Menton-bottom lip length
17	Menton-chin length
18	Anterior chin projection-nasal bridge length
19	Maximum nasal bridge breadth
20	Nose width
21	Lip width
22	Chin width

Figure 6: Reference of Facial Anthropometry [2]

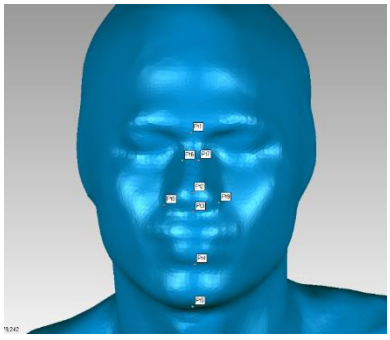


Figure 7: Point coordinate on a mesh

Based on the figure 7 above, the dimension of each participant is been calculate by using the point coordinate method. The coordinate is been align with axis x and y. So, we only need to calculate the z value to find the distance between 2 points.

2.4 Gap Analysis

When the mesh has completely meshed together, the gap between the mesh will be analysed. At first, we must know that the pocket mask contact surface. So, the contact area is been separated from the mesh. From here we will have 2 types of mesh, which is the contact piece, pocket mask and the participant. Here, we can analyse the gap between the subject, The 3 mesh will be transfer from Geomagic Studio 2012 to CATIAV5R20. In CATIAV5R20, the analysis feature that will be used is the deviation analysis under digitalized shape editor

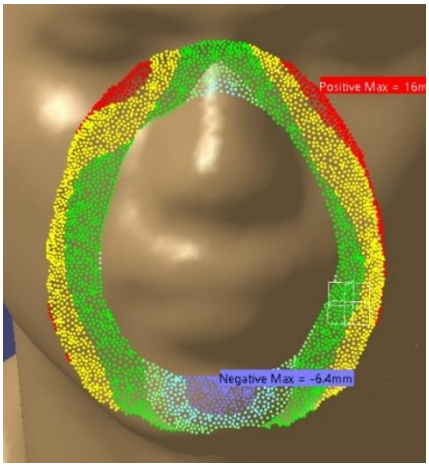


Figure 8: Pocket Mask Surface Analysis

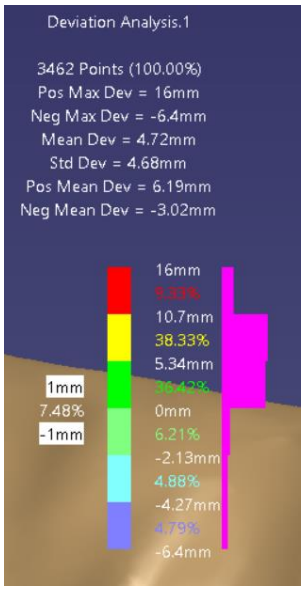


Figure 9: Gap Analysis Value & Texture Maps

3. Results and Discussion

From the analysis that was done, the result can be divided into 2 which is facial anthropometry data and also the gap analysis which consists of Stand-off Distance (SOD) and Gap Uniformity (GU) in general SOD is known as the mean deviation of all point in the object. While GU is known as the standard deviation of all points in the mesh before the contact surface of the pocket mask

3.1 Anthropometry data

. The facial anthropometry data that are been analysed is nose length (NL), nose protrusion (NP), menton-nasal bridge length (MNBL), lower face length (LFL), menton-bottom lip length-nose protrusion (MBLLNP), mentonchin-length (MCL), Anterior chin projection-nasal bridge length (ACPNBL), and maximum nasal bridge breadth (MNBB) and nose width (NS).

Table 2: Facial Anthropometry Data of Participant

Participants	Dimensions(mm)								
	NL	NP	MNBL	LFL	MBLLNP	MCL	ACPNBL	MNBB	NS
A	101.112	14.293	112.556	80.171	31.347	16.612	95.909	11.028	34.443
B	97.765	13.428	128.606	75.03	30.841	15.421	95.89	11.431	35.431
C	89.873	10.379	119.682	69.764	29.809	14.904	100.975	10.485	29.57
D	94.503	14.741	120.125	60.127	25.622	12.811	107.314	11.389	36.896
E	88.229	13.535	116.03	65.185	20.687	10.344	105.686	12.555	37.617
F	92.585	15.397	116.001	65.061	23.416	11.708	104.293	16.953	33.892
G	83.938	13.854	116.523	62.514	32.585	16.293	100.23	12.555	37.524
H	91.714	17.799	121.632	68.527	29.917	14.9585	106.6735	13.365	38.34
I	89.033	12.759	118.568	65.468	29.526	14.763	103.805	12.314	26.763
J	87.784	5.71	117.194	65.018	29.41	14.705	102.4489	11.997	41.03
Mean	91.6536	13.1895	118.6917	67.6865	28.316	14.25195	102.3224	12.4072	35.1506
Standard Deviation	5.077959	3.23849	4.332138	5.999133	3.810941	2.008684	4.081944	1.807056	4.25781

3.1 Gap Analysis

All 10 participant was analyzed in term of the gap analysis of the pocket mask. The result of the data is as follows:

Table 3: Value of SOD & GU of 10 Participants

Participant	SOD/Mean Deviation (mm)	GU/Standard Deviation (mm)
A	10.5	7.94
B	4.73	4.55
C	1.65	4.39
D	2.05	4.45
E	1.58	5.7
F	1.23	4.73
G	3.19	4.86
H	2.93	4.87
I	2.52	3.25
J	4.72	4.68
Average	3.51	4.942

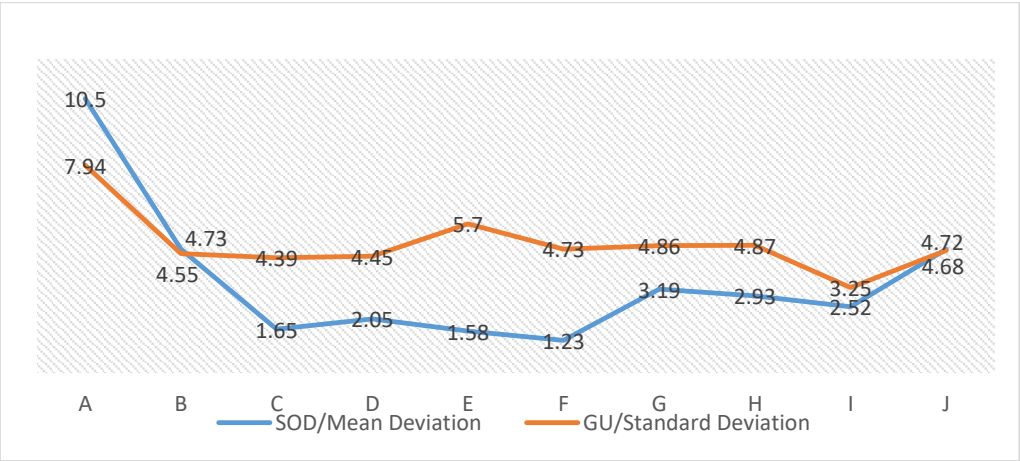


Figure 10: Graph of SOD & GU Value of 10 Participants

3.2 Discussions

Table 2 shows the facial anthropometric data of all 10 participants. the dimension of each participant with mean and standard deviation in each part of data. In overall the data shows that each participant has various anthropometric dimension, there is 1 participant which is participant A have a high value of lower face length compare to others participant, this shows that the person has long lower face compared to other participants. Participant E however have the lowest value of menton-bottom lip length, nose protrusion (MBLLNP), this proves that he has a short lower lips chin distance. Overall, all participant has similar facial anthropometry data regardless of their different type of faces.

By referring to figure 8 & 9 above, we can see the analysis of the mesh. The analysis categorized the gaps between the mesh into 4 colour groups are green, yellow, red and blue. The green indicates that the mask has the lowest value of gaps while the yellow one shows the gaps is moderate in the distance, red however show that the point is far away. Bluepoint shows the overlapping of the mask and the face. The reason while there are some overlapping occurs is that the mask is compressed during the test resulting in the deformation of skin in the chin area. The blue point can be referred to as 0 because it has already covered the area. Throughout the analysis, we knew that 43.9 % of the area are closely contacted. It is showed that green point and blue in the mesh made a total of 66,37% of the mask that covered tightly and only 9.33% show far gap and it happens in the outer layer of the mask

Based on the data that I achieved, we can see that only participants A and B have a high gaps distribution compared to other participants. This is maybe due to their face dimension. Indeed, from our previous data, we detected that both of them have the longest lower face length compared to other participants. But overall, all participant shows the lowest possible gap in the pocket mask proving that the pocket mask fit in every participant

4. Conclusion

3D system sense scanner has been used to achieve the desirable and measurable head mesh through this first analysis, which shows that every participant has various parameters regarding each of their facial data. This data achieved are in purpose on manufacture to create better respirators for Malaysian citizens in the future:

The average value of these data shows that the pocket mask has a low distance in terms of gaps. Although there is no standard provided in any previous study, the value is still acceptable and it clearly shows that most of the pocket mask is fit enough to be used. The small amount of gap that occurs can be detained by performing correct posture during the CPR process. The Malaysia Ministry of Health eventually has guided the community to perform the correct CPR process using the pocket mask [7]. Despite some errors did happen during this study due to various limitation, its show that the fit of any object can be obtained by performing this method.

Acknowledgement

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