A Comparison of Dislodged Force of Sponge Head between Initially Thai Manufactured and Japan Manufactured Sponge Brush

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Abstract

The oral sponge brush is used for oral care in bedridden patients. To reduce the imported product, we are developing our own. This study aimed to compare the retention force of the sponge head developed in Thailand to those manufactured in Japan (Sunstar BUTLER). Three groups were set for this experiment with 30 samples for each group. Group A consists of the Thai made white round shape in cross-section, group B consists of the Thai made white Leelawadee shape in cross-section, and group C consists of the Japanese made ones. The strength test of each sample in each group was performed with ISO 20126:2012(E) Standard and the data was then recorded. Three from thirty in each group were randomized to analyze the "density". The obtained data of each sponge head divided with its density will be the "Force/Density" value. The density of group A, B, and C are 16.17, 16.17, and 48.53 kg m^{-3}, respectively. The "Force/Density" value of each group was calculated. In order to investigate a significant difference between the mean values of three sponge brushes, a parametric test, Levene static, and ANOVA were carried out. The results showed a statistically significant difference between the means of each group ($F=1476.922$, $df=2$, and $p<0.05$). Multiple comparisons were performed by the Bonferroni method. The results indicated that the "Force/Density" value of group C is significantly higher than the others. We can conclude that the Japanese sponge head was the most difficult to dislodge as it required higher force. The higher the density of a sponge, the more the strength it would have.

Keywords**:** *Sponge brush, Oral care, Bedridden patient*

1. Introduction

Aspiration pneumonia is a clinical syndrome caused by aspiration of oropharyngeal or upper gastrointestinal contents into the lungs in a large volume. They are significant because of their high morbidity and mortality rate. The pathophysiology of aspiration pneumonia showed that a key mechanism that resulted in acute pulmonary inflammation was oropharyngeal colonization of potentially pathogenic organisms and macroaspiration (Marik & Kaplan, 2003; Teabeaut, 1952). Dysphagia was a significantly high-risk factor that was found (Cabre et al., 2010; Marik & Kaplan, 2003; van der Maarel-Wierink, Vanobbergen, Bronkhorst, Schols, & de Baat, 2011a, 2011b). Similarly, oral hygiene is certainly associated with high-risk factors. Many research has indicated that poor oral hygiene is related to the occurrence of pneumonia. Terpenning et al showed that a dental decay, the presence of cariogenic bacteria, and periodontal pathogens as a significantly high-risk factor (Terpenning et al., 2001). In the same way, Koichiro found some characteristics of poor oral hygiene in aspiration pneumonia patients such as mucous membrane residuals, coated tongues, and remaining roots. These encourage bacterial colonization (Koichiro, 2011). The randomized controlled trials of Yoneyama et al, one of high methodological quality, oral hygiene care and the incidence of pneumonia in 417 institutionalized elders were studies, self-caring and professional caring were compared. Their dentures were cleaned in both groups. The result displayed statistically significantly higher incidences of febrile day (RR = 2.45 and 95% CI = 1.77-3.40), pneumonia (RR = 1.67 and 95% CI = 1.01-2.75), and dying from pneumonia (RR = 2.40 and 95% CI = 1.54-3.74), in a control group. Poor oral hygiene has been correlated with an increased risk of aspiration pneumonia (Yoneyama et al., 2002). For that reason, the risk of aspiration pneumonia is lessened by performing the adequate oral hygiene care, because of the reduction of potential respiratory pathogens (Ishikawa, Yoneyama, Hirota, Miyake, & Miyatake, 2008) and the improvement of the swallowing reflex and cough reflex sensitivity (Watando et al., 2004; Yoshino, Ebihara, Ebihara, Fuji, & Sasaki, 2001).

In order to prevent aspiration pneumonia among hospitalized, institutionalized, or community-dwelling elderly, oral hygiene care plays an important role. Oral hygiene care currently consists of tooth

brushing, soft tissue cleaning, and eating function (Koichiro, 2011). Owing to the decrease and degradation of the collagen fiber, the oral mucosa of the elderly are generally thinner. Moreover, tissue repair is less than younger people (O'Reilly, 2003). Therefore, hard nylon-bristle toothbrushes are not suitable. In Japan, sponge brushes are always used to clean oral mucosa. Firstly, the oral moisturizing gel is applied to the oral cavity in order to soften the hard secretion and then brushing and mucosa cleaning by sponge brush (Ikeda et al., 2014). The buccal, gingival and palatal mucosa were wiped twice each with the sponge brush from the posterior to the anterior region (Tashiro et al., 2012). Differently, in Wales where the sponge head detached from the handle of sponge brush while a caretaker was providing oral care to the elderly. Many incidents of dislodgement and tearing of sponge head have been reported, resulting in retaining pieces of sponge in the oral cavity because sponge heads are left in water prior to use as this may affect the strength of the sponge head attachment. These can cause a choking hazard and sponge brushes were finally withdrawn from Wales in 2012 (Howells, 2013). However, it is difficult to produce an evidence-based conclusion because of different usage characteristics.

The sponge brushes were first produced in Thailand to lessen the cost of the imported sponge brushes. The design of the sponge head consists of a sponge-like head with ridges. It was the Thai made white Leelawadee shape in cross-section. The texture of the ridges provide adequate cleaning of the oral mucosa and sufficient removal of debris but the morphology of the ridges may reduce the overall strength of the sponge head by reducing its volume. The other designs provide a sponge-like head without ridges. It was the Thai made white round shape in cross-section. Nevertheless, the standard is not established when concerning product safety and product efficiency standard. According to the previous issues discussed in Wales, we are interested in the study of sponge brushes which are manufactured in Thailand in terms of retention force of sponge head compared to the commercial product used in Japan.

2. Objectives

To perform an in vitro investigation on the sponge head retention of different manufactured sponge brushes (Two novel Thai-produced sponge brushes; a combination of two shapes (round and Leelawadee), King Dental Innovation Foundation; KDIF, Thailand and Sakura shape, Sunstar BUTLER, Japan).

3. Materials and Methods

3.1 Sponge brushes

The testing procedure was performed by a single operator in the same laboratory. A total of three manufactured sponge brushes were used, the group A was the Thai made white round shape in cross-section, the group B was the Thai made white Leelawadee shape in cross-section, and the group C was the Japanese made Sakura shape in cross-section (Sunstar BUTLER, Japan) as shown in Figure 1. For each group, thirty samples were tested.

3.2 Foam density test

Firstly, the two types of foam were evaluated for their density (Thai made foam and Japanese made foam). The density of the foam can be calculated from the weight of foam in the air per unit volume of the specimen (Duanghathai & Ellis, 2005). Three sponge brushes of Thai made groups and Japanese made group were randomly selected. The foam of sponge heads was cut into a cubic shape with a thickness of 3 mm, a width of 5 mm, and a length of 5 mm. The diameter of each specimen was measured with a digital caliper (Digimatic caliper, Mitutoyo Corporation, Kawasaki, Japan) and was accurately weighed on a balance (Digital balance, ATY224, SHIMADZU, Japan). The volume of each specimen was analyzed by a Micro-CT (SCANCO Medical, Switzerland) (Blazejczyk, 2018). The densities were then calculated. Three specimens in each foam were tested. The reported value was the mean of those observed.

3.3 Sponge head retention test

In order to compare the sponge head retention force, strength test measurement was performed using a universal testing machine (EZ-S, SHIMADZU, Japan). The test was performed according to ISO 20126:2012(E): Method 5.4 (Standards, 2012). Thirty samples of each group were tested, then the force was recorded.

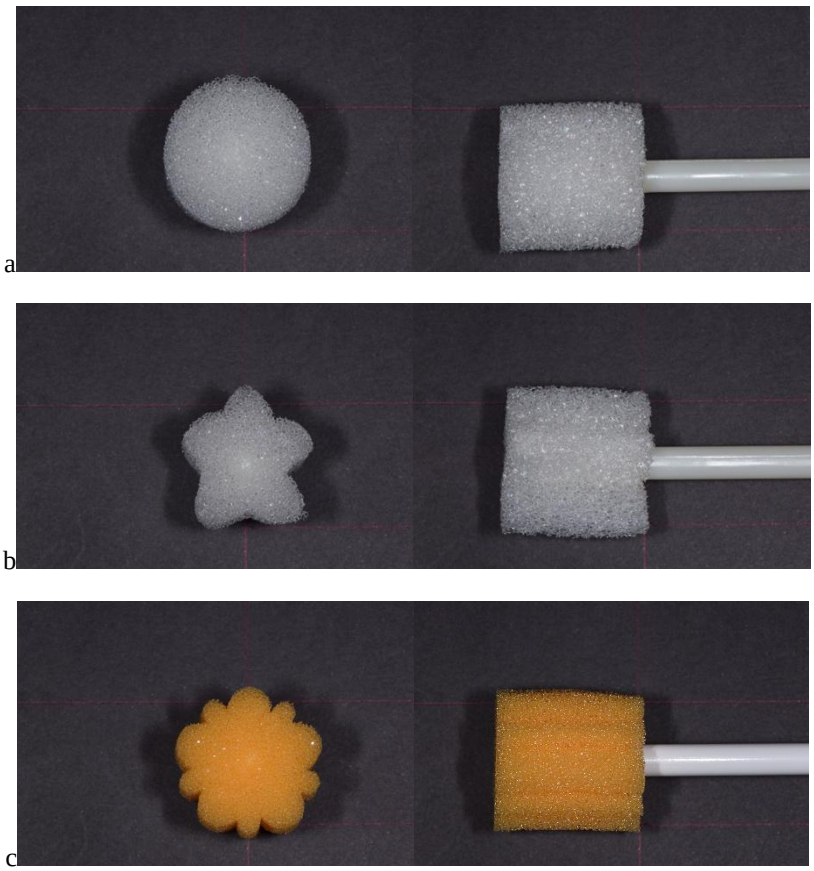

Figure 1 – (a) White sponge head with round shape in cross-section; (b) White sponge head with Leelawadee shape in cross-section; (c) Sponge head with Sakura-shaped in cross-section

3.4 Analytical methods

The obtained force of each sponge head divided with its density were "Force/Density" value. To investigate the significant difference between the mean values of three sponge brushes, a parametric test, Levene's test, and ANOVA were carried out. Multiple comparisons were performed by the Bonferroni method. All tests were conducted with a statistic significant set at $\alpha = 0.05$ using SPSS version 17.0 (Chicago, IL, USA).

4. Results and Discussion

4.1 The densities of foams

The densities were calculated according to a relationship (Duanghathai & Ellis, 2005).

$$\text{Density (kg/m}^3\text{)} = \text{Sample weight (kg)/volume (m}^3\text{)}$$

The density of group A, B, and C are 16.17, 16.17, and 48.53 kg m^{-3}, respectively. The results are summarized in Table 1 and Table 2. Considering the "weight/volume" value, the Japanese made foam provided a higher average density than the Thai made foam.

Table 1 Average foam density of the Thai made white sponge head

Test specimens from group A and B	Total volume (mm^3)	Weight (g)	Density (kg/m^3)	Average density (kg/m^3)
n1	308.9670	0.0050	16.18	
n2	299.8324	0.0048	16.01	
n3	306.1318	0.0050	16.33	16.17

Table 2 Average foam density of the Japanese made sponge head

Test specimens from group C	Total volume (mm^3)	Weight (g)	Density (kg/m^3)	Average density (kg/m^3)
n1	189.5751	0.0094	49.58	
n2	199.6633	0.0093	46.58	
n3	200.3068	0.0099	49.42	48.53

4.2 The sponge head retention test of different manufactured sponge brush

The average of "Force/Density" (F/D) value from each group was compared to the significant difference. Statistical analysis was performed using the Shapiro-Wilk test for normality determination. The data follows a normal distribution ($p > 0.05$). The Levene statistic determined a homogeneity of variance ($p > 0.05$). According to the ANOVA ($p < 0.05$), two or more groups are significantly different from each other in one or more characteristics. With different densities, lower value of F/D implied the higher strength of a sponge head, the Thai made sponge head exhibited significantly less strength when compared to the Japanese made sponge head. On the other hand, with the same density, the higher value of F/D implied the higher strength of sponge head, star shape exhibited significantly less strength when compared to the round shape. The results are summarized in Table 3 and Table 4.

Table 3 ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
"Force/Density" value	Between Groups	3.318	2	1.659	1476.922	0.000
	Within Groups	0.098	87	0.001		
	Total	3.416	89			

Table 4 Multiple Comparisons Bonferroni

Dependent Variable	(I)group3	(J)group3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
"Force/Density" value	group C	group B	-0.37164*	0.00865	0.000	-0.3928	-0.3505
		group A	-0.43549*	0.00865	0.000	-0.4566	-0.4144
	group B	group C	0.37164*	0.00865	0.000	0.3505	0.3928
		group A	-0.06385*	0.00865	0.000	-0.0850	-0.0427
	group A	group C	0.43549*	0.00865	0.000	0.4144	0.4566
		group B	0.06385*	0.00865	0.000	0.0427	0.0850

*. The mean difference is significant at the 0.05 level.

4.3 Discussion

This study aimed to compare the sponge head retention force of the sponge brush developed in Thailand to those manufactured in Japan (Sunstar BUTLER, Japan). Japanese sponge brush (group C) was selected as a control group because it is a commercial product available in Japan. Two novel Thai made sponge brushes were experimental groups. In this study, the null hypothesis was rejected. Significant differences in the sponge head retention were shown when using different manufacture sponge brushes.

The sponge head retention test was selected due to the safety concern. In order to promote the safety of these products for their intended use, test methods for the physical properties of the sponge head

were carried out. According to the incident in Wales(Howells, 2013), the dislodgement of the sponge head that retained in the oral cavity can be hazardously choking, so a commercial product was chosen for the test. However, the outcome still not represent the whole sponge brush which is a limitation of this study. Furthermore, the properties or the performance of the products can be measured. "Force/Density" value should be calculated in order to compare the sponge head retention. The force should be divided by their density to reduce inherent variability. The force data was determined to follow ISO 20126:2012(E): Method 5.4 (Standards, 2012). On the grounds that there is still no safety and efficiency standards test for the sponge brushes. ISO 20126:2012(E) was adopted. This international standard was used to evaluate the physical properties of manual toothbrushes. This method covers the determination of tuft retention, fatigue resistance, chemical challenges, and impact strength handling. In this study, the tuft retention test (method 5.4) was selected, it can measure and indicate the retention force of sponge head from its handle.

The comparison of sponge head retention among different densities of the foam showed that Japanese sponge head retention is significantly higher than the Thai made sponge head. When comparing the retentions of the same foam density, the round shape showed significant higher strength than Leelawadee shape in cross-section. In conclusion, the higher density foam has more strength than the lower density foam (Ashida, 2007; Lee, Park, & Ramesh, 2007; Lee & Ramesh, 2004). Therefore, Japanese sponge head was the most difficult to dislodge in these test conditions.

For better physical properties of Thai manufactured sponge head, we suggest to re-design it in higher foam density and shape variations testing.

5. Conclusion

Within the limitation of the study, our results can conclude that the Japanese sponge head was the most difficult to dislodge as it required a higher force. The density of the foam is one of the factors that influence the effectiveness of a sponge head. The higher the density, the higher the cost of the foam. Besides of density, some aspects still need to be considered such as fatigue resistance, chemical challenges, and impact strength handling.

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