Measurement Of Bristle Wear In Biodegradable Toothbrushes: A Three Month Observational Study

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Abstract

BACKGROUND: Tooth brushing is the most widely used mechanism for personal plaque control and is considered important for maintaining one's periodontal health. Toothbrushes wear out and lose their ability to clean. The extent to which toothbrush bristles are worn out is important to determine the effectiveness of the brush. **METHODS:** A total of 40 children aged 8-11 years residing in Girls Orphanage in East Bangalore city were included in the study. They were divided into four groups of 10 each, Group1- I am Earth Conscious®, Group2- September Forest®, Group3- BambooIndia®) and Group4-Colgate Flexi® (control). Standard brushing was demonstrated to them to follow. After three months, the toothbrushes were collected and assessed for wear. **RESULTS**: Using Kruskal Wallis Test, the mean values of toothbrush Wear Index (WI) of the four study groups were calculated and compared. It was found that there was a significant difference in their mean values ($p<0.001$) at the end of three months. Using Mann Whitney Post hoc Test, an inter-group comparison of Wear Index was done and it was found that I am Earth Conscious® and September Forest® showed similar mean values and BambooIndia® showed similar mean values as Colgate Flexi® toothbrush. Using post usage photographs of the brushes, it was found that September Forest® had the highest Subjective Wear Rate. **CONCLUSION:** BambooIndia® toothbrush showed similar efficiency as Colgate Flexi® toothbrush. It can be a promising alternative to the already available commercial toothbrushes.

Keywords: Biodegradable toothbrushes, toothbrush, child toothbrush, toothbrush wear, bristle wear.

INTRODUCTION

Tooth brushing is the most widely used mechanism for personal plaque control and is considered important for maintaining one's periodontal health. [1,2] Maintaining one's oral health and keeping it free from plaque accumulation will keep the individual free of gingivitis and other periodontal problems. [3-5]

Toothbrushes, however, do not last a lifetime.[6] There is limited scientific data available to indicate when a toothbrush should be replaced.[7] Commonly, one senses the loss of effectiveness of his/her toothbrush when it is worn out. The more the brush is worn, the more it loses its effectiveness, owing to the bending of the filament tips, which will not adequately disrupt the plaque.[8]

The extent to which toothbrush bristles are worn out is important to determine the effectiveness of the brush. According to studies published, the average replacement of a toothbrush ranges from 2-3 months. [9-11] The American Dental Association (2019) recommends changing one's toothbrush every 3 to 4 months or even sooner if the bristles become frayed.[11]

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Plastic pollution is a global concern, owing to the fact that it has a negative impact on the marine and terrestrial wildlife. When plastics began to be a part of our everyday life, they were claimed as hi-tech materials and a material of economic abundance and also of human control over nature. However, the nature of durability and impermeability that make plastics so convenient also makes it to not decompose.

So, as a small step towards change, to reduce the use of plastic in our day-to-day life, biodegradable toothbrushes have been made available. These toothbrushes have handles made from wood or bamboo and bristles made of natural fibres or synthetic nylon and BPA (Bisphenol A) free plastics. There have been no studies in regard to the wear rate of these new toothbrushes. This study aimed to therefore determine the wear rate of biodegradable toothbrushes in a three-month study period.

MATERIALS AND METHODS

The study was conducted through dental health camps in a Girls Orphanage in East Bangalore city with a written consent from the Head of the Institution. The study was commenced after obtaining approval from the Institutional Ethical Committee and Review Board. The sample size of the study was estimated to be 40 keeping the power of the study at 80% and the margin of the error at 5%.

Inclusion criteria:

1. 8–11-year-old children.
2. Subjects who are permanent residents of the orphanage.
3. Subjects who are physically and mentally fit.
4. Subjects who are willing to participate in the study

Exclusion criteria:

1. Subjects below 8 years and above 11 years.
2. Subjects with any previous medical history and on antibiotic therapy for past one month.
3. Subjects who are uncooperative/ unwilling for clinical examination during the study.

Biodegradable toothbrushes: I am Earth Conscious®, BambooIndia® and September Forest® and commercially available Colgate Flexi® toothbrushes were used in the study

Prior to their distribution to the children, measurements of each toothbrush were recorded using Vernier Callipers (Mitutoyo digital Vernier) as shown in **Figure 1**. Standard photographs from all views (cross-sections and aerial view) of the head of the toothbrushes were taken as shown in **Figure 2 & 3**.

A routine oral examination was done, after which a blinded examiner divided the children into 4 groups of 10 each- Group I- I am Earth Conscious®, Group II- September Forest®, Group III- BambooIndia® and Group IV- Colgate Flexi® (control group). Each child was blinded to the specific toothbrush provided and a standard toothpaste (Colgate®) was provided to them during the period of the study.

The children were instructed to brush twice daily for the next three months with the provided toothbrushes. Standard brushing technique was demonstrated to the children to follow and the video of the same was provided to the supervisor for reference.

At the end of three months, all the toothbrushes were collected and assessed using Rawls Wear Index and Subjective Wear Rate.

Measurements (using Vernier Calliper) of the toothbrushes post their three months usage was recorded and Wear Index was calculated using the formula:

$$WI = \frac{W_f^s - W_a^s + W_f^e - W_a^e}{2L_0}$$

where, WI= Wear Index; W = maximum brush width measured along one side, W_s, and one end, W_e, of the brush head, and at the anchored (zero splay) ends, W_a, and the free (splayed) ends, W_f, of the bristles; L_0 = maximum brush trim height before the brush is used, or the length of the highest standing bristles long as a vertical bristle remains as shown in **Figure 1**

Similar standard photographs of the used toothbrushes were taken to assess the Subjective Wear Rate as shown in **Figure 4 & 5** using a subjective rating scale that consists of a series of four numbers increasing from zero to three as shown in **Table 1** and **Figure 6**

STATISTICAL ANALYSIS

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., was used to perform statistical analyses. The level of significance was set at $p<0.05$.

RESULTS

There Using Kruskal Wallis Test, the mean values of toothbrush Wear Index (WI) between the four study groups were compared at the end of three months, and it was found that there was a significant difference in their mean values (p<0.001), as shown in **Table 2**.

Using Mann Whitney Post hoc Test, an inter-group comparison of Wear Index, where it was noted that between Group 1(I am Earth Conscious®) and Group 2 (September Forest®) there was no significance in their mean values, whereas when Group 1 was compared with Group 3 (BambooIndia®) and Group 4 (Colgate Flexi®), there was a significant difference noted in their mean values. (p<0.05) as shown in **Table 3**.

When Group 2 mean values were compared with Group 3 and Group 4, there was significant difference noted.

Lastly, when Group 3 was compared with Group 4, no significant difference was noted, indicating that their Wear Index was similar.

Using the Subjective Wear Rating (WR) and the post usage pictures, all the toothbrushes were assessed and it was found that I am Earth Conscious® had the maximum score of 2 (medium) and September Forest® had the maximum score of 3(heavy), whereas, BambooIndia® and Colgate Flexi® had a maximum score of 2 (medium). September Forest® had the highest wear rate as compared to the other three groups. BambooIndia® and Colgate Flexi® toothbrush showed similar wear rate as shown in **Figure 3 & 4.**

DISCUSSION

The biodegradable toothbrushes (I am Earth Conscious® ,BambooIndia® and September Forest® have their handles made of bamboo and BPA (Bisphenol A) free Nylon-6 bristles, which are biodegradable over a period of time. The widely available Colgate Flexi® toothbrush made of plastic was used as a control as it is commonly used toothbrush.

As one step in a systematic approach to check the ability of brushes to remove plaque and it's relation to toothbrush wear, Rawls et al., developed a Wear Index to measure bristle splaying quantitatively, and a Wear Rating system to rank brushes according to their overall state of deterioration (Rawls and Mkwayi-Tulloch, 1988)[12].

This study assessed toothbrush wear after 3 months of usage of the allotted toothbrushes using Rawls toothbrush Wear Index and it was found that there was a significant difference in all the four toothbrush groups.

Martijn P. C. Van Leeuwen et al.,[13] investigated the extent of degree of toothbrush wear of 3-monthold manual toothbrushes and their influence on plaque scores, and they found toothbrushes with extreme wear were less effective than those with no or light wear. Pradeep S. Tangade et al,,[14] conducted a study to verify the impact of the Progressive Toothbrush Bristle Flaring on plaque control efficacy of toothbrush and they concluded that progressive increase was seen in the plaque scores with increase in toothbrush bristle flaring. Parichehr Behfarnia et al.,[15] assessed the correlation of duration of use of a toothbrush and its wear and its relationship to Plaque Index (PI) and tapering of toothbrush filaments after three months of use was evaluated as well. They concluded that the duration of use and wear of toothbrush alone does not affect the quality of plaque removal. On the contrary, Louise M. E. Hogan et al.,[16] compared the effectiveness of new and 3-month-old worn brush heads in plaque removal using a rotation–oscillation-powered toothbrush and found that rotation–oscillation-powered toothbrushes with 3-month-old brush heads exhibiting various degrees of wear were as effective as new brush heads in plaque removal. Yoshino Kaneyasu et al.,[17] assessed the degree of bristle splaying of used manual toothbrushes and investigated their plaque removal efficacy. The toothbrushes were assessed at 1, 2 and 3 months and concluded that toothbrushes became less effective after two months of use. Rayia Jasim AL-Naimi [18] assessed the influence of toothbrush wear on plaque index (PI) and gingival (GI) index for a period of three months and concluded from the results they obtained, that the capacity to remove dental plaque is much related to toothbrush wear.

In our study after a period of three months, when each toothbrush was individually compared with each other, it was found that between Group 1(I am Earth Conscious®) and Group 2 (September Forest®) there was no difference in their Wear Index and Subjective Wear rate values, whereas when Group 1 was

compared with Group 3 (BambooIndia®) and Group 4 (Colgate Flexi®), there was a difference in their mean values. When Group 2 was compared with Group 3 and Group 4, there was significant difference noted in their Wear Index and Subjective Wear Rate. Also, when Group 3(BambooIndia®) was compared with Group 4 (Colgate Flexi®), no significant difference was noted in their values, indicating that their Wear Index and Wear Rate were similar. This could be attributed to the Nylon-6 material of the bristles.

In the Subjective Wear Rate assessment, September Forest®toothbrushes showed most wear and BambooIndia® toothbrush showed the least and similar Wear Rate as the control toothbrush Colgate Flexi®.

CONCLUSION

From our study we can conclude that BambooIndia® toothbrush showed similar efficiency as Colgate Flexi® toothbrush. It can be a promising alternative. As these biodegradable brushes have also been made more accessible, a proper standardization of these brushes and awareness programs regarding the need of using biodegradable toothbrushes is required. Furthermore, studies comparing these brushes with other types of brushes, in a larger population could be helpful.

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Scale Rating	Appearance of the Brush	Probable Wear
0	One cannot be sure if the brush has been used or not.	None to Slight
		(0-25%)
1	The bristles appear to be spread apart within many of the tufts.	Low
		(26-49%)
2	All tufts are spread apart, many overlap other tufts, and many bristles are curled and/or matted.	Medium
		(50-75%)
3	Most tufts overlap and are matted together. Many curled and bent bristles can be seen.	Heavy
		(76-100%)

Table 1 Subjective rating scale for judging overall toothbrush deterioration and wear

Parameters	Groups	N	Mean	SD	Min	Max	P-Value
WI	Group 1	10	0.263	0.060	0.15	0.34	<0.001*
	Group 2	10	0.423	0.100	0.30	0.57	
	Group 3	10	0.202	0.148	0.03	0.50	
	Group 4	10	0.181	0.033	0.14	0.23	

Table 2: Mean values of toothbrush Wear Index of 4 groups at 3 Months period using Kruskal Wallis Test

Parameters	G1 vs G2	G1 vs G3	G1 vs G4	G2 vs G3	G2 vs G4	G3 vs G4
WI	0.32	0.02*	0.01*	0.01*	0.003*	0.60

Table 3: Comparison of mean differences between groups at 3 months using Mann Whitney Post hoc Test
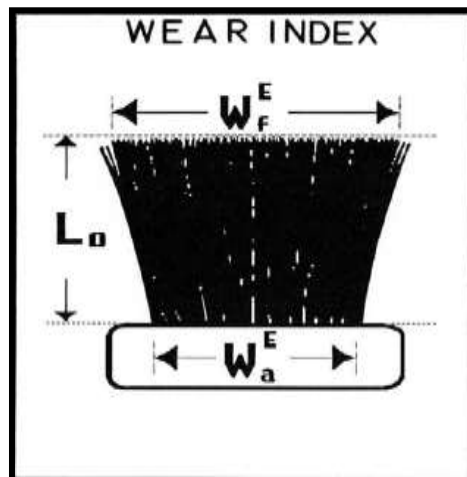
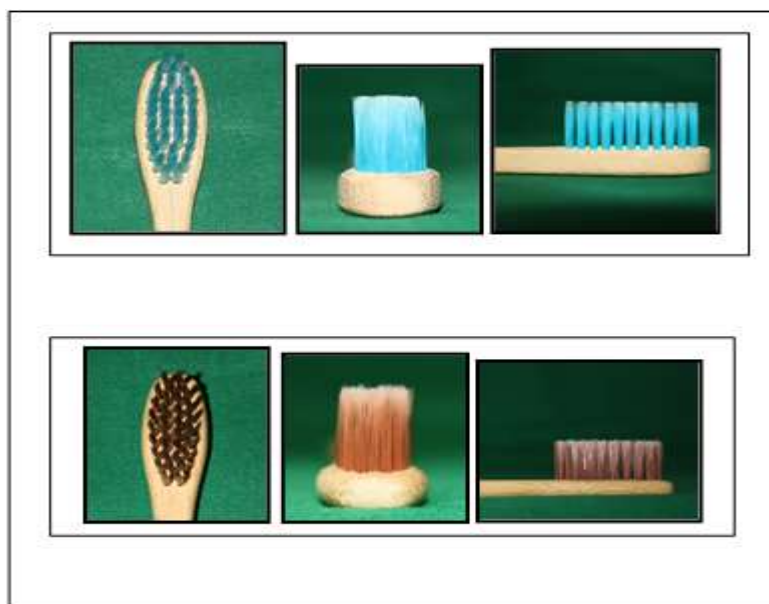**Figure 1: Method used to determine weaindex (WI)**

Figure 2: Pre-usage photographs of I(I am Earth Conscious®) and II (September Forest®)

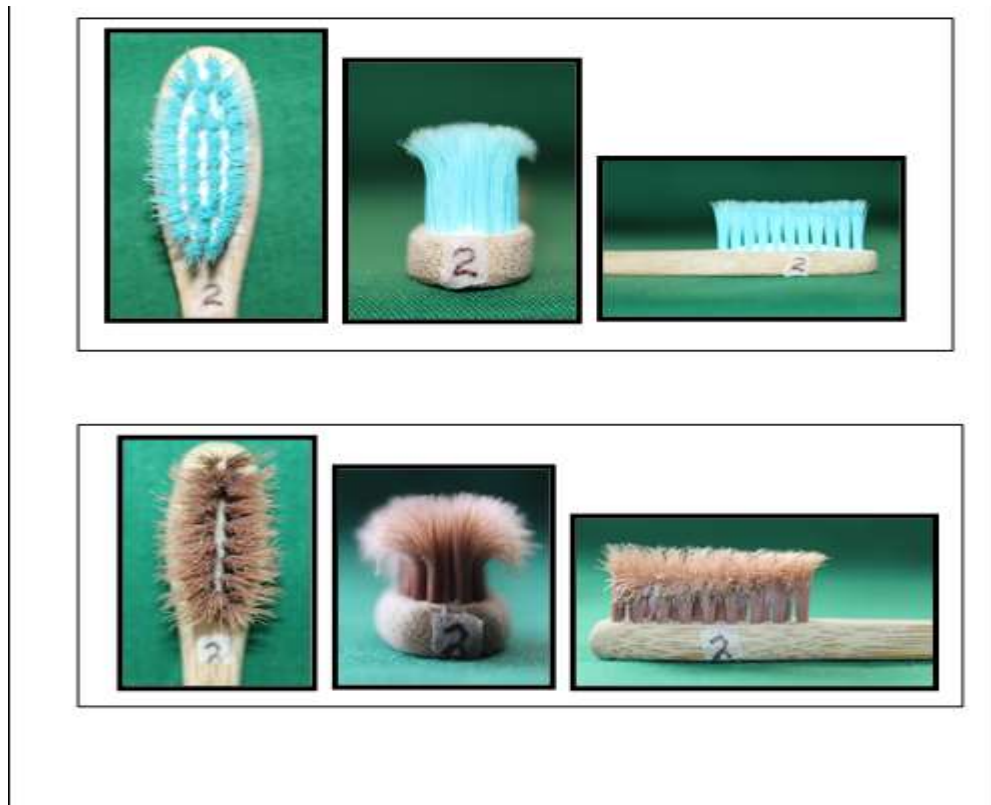**Figure 3: Pre-usage photographs of III (BambooIndia®) and IV (Colgate Flex**

Figure 4: Post-usage photographs of I(I am Earth Conscious®) and II (September Forest®)
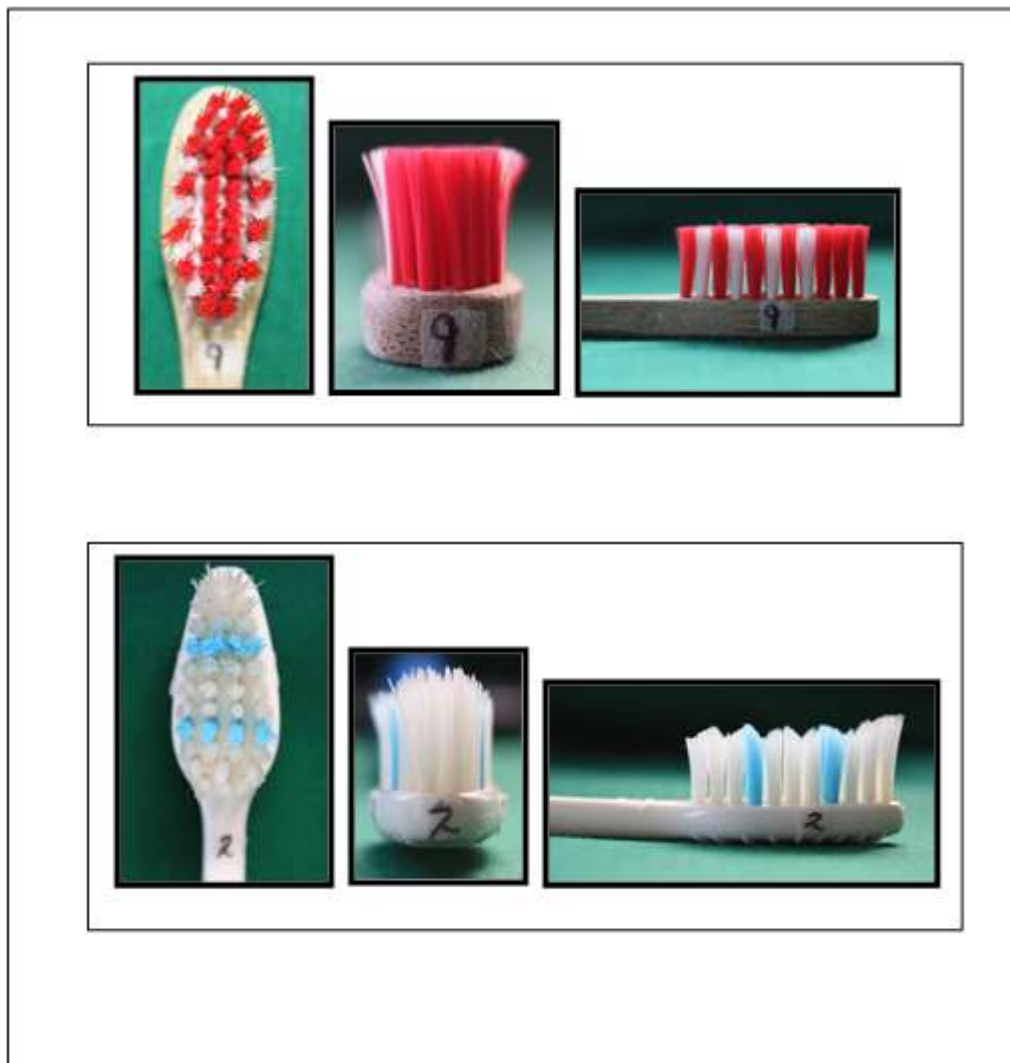
Figure 5: Post-usage photographs of III (BambooIndia®) and IV (Colgate Flexi®)
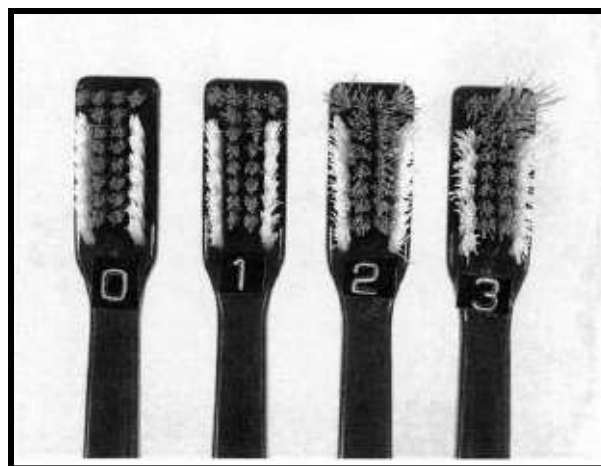

Figure 6: Standards of comparison for determining wear rating: 0 = None, 1 =Low, 2 Medium, and 3 High.