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A Comparative Evaluation of Plaque Removal Efficacy of Toothbrushes with Herbal and Charcoal Bristles: A Randomized Clinical Trial

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ABSTRACT

Aim and Objective: *Oral hygiene is an indispensable need of a basic mankind which can impact an individual's oral functions and social interactions, and it is more likely to influence the overall well-being and quality of life. As days passes by many innovations by the manufacturers is done on manual toothbrushes to transform pleasurable experience by the individuals, because of its affordability and primitive practice by most of the population. So, this study aims to compare the efficacy of toothbrush bristles of charcoal, herbal and regular toothbrush in reducing dental plaque and gingivitis.*

Method and materials: *Sixty participants were randomly assigned to three groups. Group 1 used charcoal-infused bristles, Group 2 used herbal-infused bristles, and Group 3 used regular nylon bristles. Baseline and one-month follow-up assessments included the Plaque Index (Turesky et al.) and Gingival Bleeding Index (Ainamo & Bay) to measure Plaque and Gingival Bleeding index.*

Results: *Charcoal Toothbrush achieved the highest reduction rate in GBI (7.40%), and highest PI reduction score (1.88) comparatively, making it the most effective for plaque and gingival bleeding reduction.*

Conclusion: *Charcoal infused bristles are effective in plaque removal and gingival bleeding reduction.*

Key words: *Charcoal toothbrush, herbal toothbrush, oral hygiene, dental plaque, gingivitis*

I. Introduction

Dental plaque is a transparent, robust substance composed of intricate networks of microbial colonies intertwined with various organic and inorganic derived sources like saliva, gingival crevicular fluid, and bacterial secretions, that are embedded within a carefully structured polysaccharide matrix. Any disturbance in the balance of these microbial communities may lead to dysbiosis, which triggers the onset and progression of periodontal disease[1].In order to maintain proper disease free and odour free oral cavity, oral hygiene practice plays an indispensable role for maintaining overall well-being that influences an individual's oral hygiene status and social interactions thereby promoting overall health and quality of life [2].In-spite of various advancements, mechanical removal of plaque biofilm through proper tooth brushing is an effective and preventive measure against periodontal diseases [3].Among all the mechanical toothbrushes, conventional tooth brushing is considered to be the most frequently and widely used oral hygiene aid. As days passes by many innovations by the manufacturers is done on manual toothbrushes to meet the demand for natural and alternative dental care products with latest technological advances and gleaning information ranging from stroke pressure to oral hygiene habits, thereby transforming pleasurable experience by the individuals[4,5].Building on the advancements in natural toothbrushes, which commonly feature antimicrobial ingredients like neem, miswak, charcoal, and clove, we are pioneering the development of a 3-in-1 herbal toothbrush. This innovative toothbrush combines neem, clove, and tulsi in the bristles, and we are the first to explore its potential benefits in our study. Hence the present study was conducted to evaluate and compare the efficacy of a manual toothbrush with bristles containing charcoal and herbal (clove, tulsi and neem) in reducing dental plaque and gingivitis.

II. Materials and methods

This randomized, in-vitro clinical study was conducted at SRM Kattankulathur Dental College and Hospital (Deemed to be University), Chengalpattu, Tamil Nadu, India. Ethical approval for the study was granted by the institutional review board under reference number SRMIEC-ST0724-1539.

The aim of the study was to assess and compare the effectiveness of toothbrushes with charcoal-infused bristles and herbal-infused bristles in reducing dental plaque and gingivitis. The study involved 60 male and female participants, all of whom employed modified Bass technique for brushing. Participants were randomly assigned to three intervention groups through a lottery system.

Eligible participants, aged 18 and above, were selected at random and provided informed consent before participating in the study, which took place from March to July 2024. The groups were as follows:

Group 1: 20 participants used a toothbrush with charcoal bristles.
Group 2: 20 participants used a toothbrush with herbal bristles.
Group 3: 20 participants used a regular nylon-bristle toothbrush

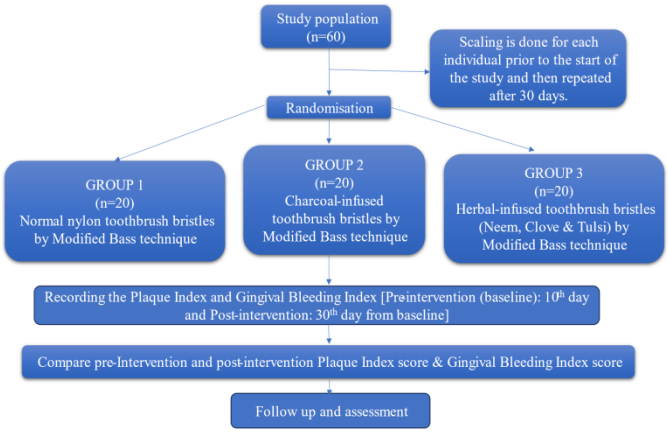

Figure 1: Flowchart for study methodization

2.1.Inclusion criteria:
The study included participants who exclusively used conventional toothbrushes, maintained satisfactory oral hygiene, had mild to moderate gingivitis with at least 20% bleeding on probing sites, had a minimum of 20 teeth, who were willing to follow the study schedule.

2.2.Exclusion criteria:
The study excluded subjects with mucogingival disorders, alcohol consumption, smoking, tobacco use, those using mouthwashes or interdental cleaning aids, individuals with no underlying systemic conditions, people taking medications that affect gingival tissue, individuals with limited manual dexterity, pregnant or lactating women and those not undergoing active orthodontic treatment (such as bands or retention wires).

Prior to the commencement of study, a thorough patient history and intraoral examination were conducted, and informed consent was obtained from each participant. To ensure uniform baseline scores, all participants underwent complete ultrasonic scaling and were instructed on proper tooth brushing by modified Bass technique, with a recommendation to brush twice daily for two minutes. Baseline scores were recorded on the 7th day using a two-tone erythrosine dye solution to assess Plaque index. The modified plaque scoring system by Turesky et al. was employed, as it offers a clear and objective definition for each score in the index[6].Initially, the patient is instructed to rinse their mouth thoroughly to remove any food debris and excess saliva. A water-based lubricant is then carefully applied to avoid staining the lips. Next, the teeth are air-dried. The solution is applied to the teeth using a swab or a small cotton pellet, covering all the crowns of the teeth. The patient is then asked to spread the solution over all the surfaces of their teeth using their tongue. Finally, the distribution of the solution is checked, and the patient is advised to rinse their mouth. Red or pink biofilm signifies newly formed, thin plaque, typically found above the gumline. Blue biofilm represents thicker, older, more persistent plaque, usually located at or just beneath the gumline, particularly on the proximal surfaces and areas where brushing or flossing is difficult; it may also be linked to the presence of calculus [7].Gingivitis was evaluated using the Gingival Index by Ainamo and Bay (1965), as this index specifically focuses on qualitative changes in the gingival soft tissues. Participants were randomly assigned to three intervention groups through a lock lottery system each receiving a toothbrushand then recalled on the 30th day for post-intervention evaluation. All indices were assessed by a single investigator to prevent inter-rater variation. The investigator had been trained and tested for accuracy and reliability, achieving over 90% reproducibility before the study commenced.

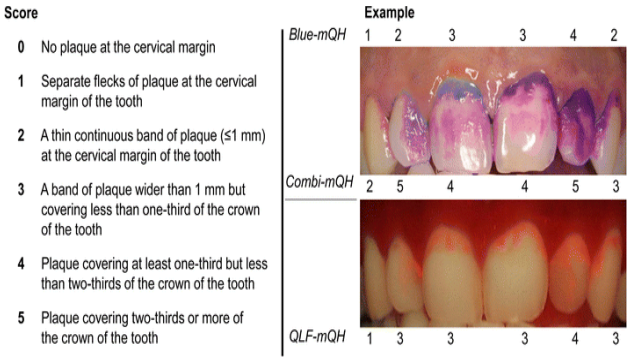

Figure 2: Plaque Index - Turesky Et Al

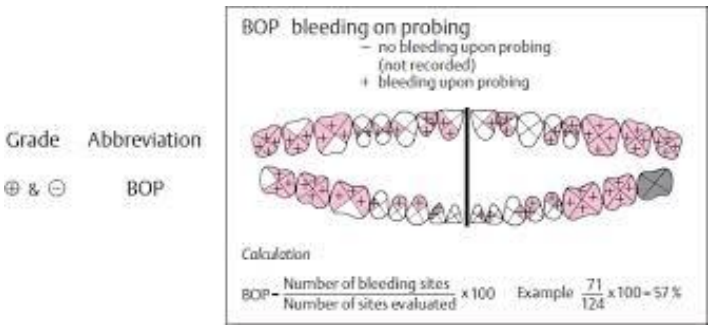

Figure 3: Gingival Bleeding Index - Ainamo and Bay

Figure 4: Gingival Bleeding Index and Plaque Index Assessment

Figure 5:Two-tone dye application

Figure 6: After 2 minutes of rinsing the dye

III. Statistical Analysis

The author performed power analysis with a confidence interval at 95% and the data was collected by the assistant and performed randomisation. Baseline GBI and PI were recorded at 7th day for each participant in all groups. After 30 days of regular use, post-intervention GBI and PI values were measured again. Mean reductions were calculated. Independent t-test for intergroup comparison was conducted to assess statistical significance.

TABLE 1: TOOTHBRUSH WITH NYLON BRISTLES (Paired Sample t test)

INDICES	MEAN BASELINE	AFTER 30 DAYS	MEAN REDUCTION	P value
GBI	14.24	9.62	32.45	<0.001
PI	2.06	1.76	14.56	<0.001

TABLE 2: TOOTHBRUSH WITH HERBAL (NEEM, TULSI & CLOVE) BRISTLES

INDICES	BASELINE	AFTER 30 DAYS	MEAN REDUCTION	P value
GBI	14.43	6.39	55.72	<0.001
PI	2.43	1.79	26.34	<0.001

TABLE 3: TOOTHBRUSH WITH CHARCOAL BRISTLES

INDICES	BASELINE	AFTER 30 DAYS	MEAN REDUCTION (%)	P value
GBI	15.67	3.92	74.98	<0.001
PI	2.05	1.65	19.51	<0.001

TABLE 4: COMPARISON OF PI & GBI AMONG TOOTHBRUSHES AT BASELINE AND AFTER 30 DAYS

TOOTHBRUSHES	GBI (PRE-BRUSHING)	GBI (POST-BRUSHING)	PI (PRE-BRUSHING)	PI (POST-BRUSHING)	P-VALUE
NYLON	14.24	9.62	2.06	1.76	.000
HERBAL	14.43	6.39	2.43	1.79	.002
CHARCOAL	15.67	3.92	2.05	1.65	.267

IV. Results

At baseline, Table 1,2,3 demonstrates the p-value of <0.001 indicating a significant reduction in both GBI and PI values for all three toothbrush types, with the PI scores for charcoal, herbal, and nylon groups being 2.05, 2.43, and 2.06, respectively. The baseline GBI scores for the charcoal, herbal, and nylon groups were 15.67, 14.43, and 14.24, respectively. After 30 days, the PI and GBI scores showed statistically significant improvement in both groups, except for the charcoal-bristled toothbrush, which had a p-value of 0.267, indicating a significantly greater reduction in GBI and PI compared to the other two toothbrushes.

In conclusion, Table 4 clearly shows that the charcoal-bristled toothbrush was more effective in reducing gingival bleeding and plaque than both the herbal and nylon-bristled toothbrushes, making it a good option for individuals who prefer using a regular manual toothbrush for their oral hygiene routine.

V. Discussion

Effective removal of dental plaque is essential for the prevention and management of periodontal diseases, as plaque build-up is a primary contributor to gingival and periodontal inflammation. Tooth brushing serves as the cornerstone of oral hygiene and is universally endorsed worldwide. A noticeable reduction in gingival bleeding is a strong indicator of oral health, demonstrating the presence or absence of underlying inflammation and signalling the early stages of periodontal disease[8].

Despite the widespread emphasis on good oral hygiene, many individuals struggle with conventional tools, such as standard toothbrushes and floss. Common challenges, including improper brushing techniques, insufficient bristle reach in difficult interproximal and sub-gingival areas, and discrepancies in brush design, can severely impede effective plaque removal and gum health management[9]. These issues create a compelling need for innovative toothbrush designs. By introducing advanced options, such as herbal and charcoal-infused bristles, we can significantly enhance mechanical cleaning efficiency, reduce microbial load, and minimize gingival bleeding. These innovations promise to transform oral hygiene practices and lead to markedly improved overall oral health outcomes globally.

This study compares plaque and gingival bleeding index scores across three different manual toothbrushes, focusing on the effectiveness of 3-in-1 herbal-infused toothbrush bristles and charcoal bristle toothbrushes for optimal plaque removal and reduction of gingival bleeding.

Tulsi, or Holy Basil, is particularly effective in promoting bacterial lysis on tooth surfaces and in saliva. It also disrupts bacterial adherence to teeth. Additionally, Tulsi's astringent properties help tighten the gums thereby preventing tooth loosening, as demonstrated by the study conducted by Bhuvaneshwari Gangadharamurthy Nadar et al. in 2019[10].

Neem extracts have demonstrated a robust ability to inhibit the growth of Streptococcus mutans and significantly reduce bacterial adhesion in laboratory studies. It is also highly effective in treating infections, tooth decay, bleeding gums, and sore gums, in accordance with the study conducted by Akhilkesh Chandra et al. in 2018[11].

Clove oil stands out as a powerful antioxidant that effectively scavenges free radicals while exhibiting antifungal properties. Its bactericidal action against multi-resistant Staphylococcus species further underscores its efficacy. Moreover, clove oil is well-documented for its analgesic, local anesthetic, and anti-inflammatory properties, establishing its significance in oral healthcare. Its effectiveness in reducing plaque index is supported by the findings of Kothiwale et al., who reported comparable antiplaque efficacy with the use of a clove-infused mouth rinse[12].

Charcoal toothbrushes have also gained popularity due to their exceptional absorbent properties, which enhance oral cleaning by dismantling plaque biofilm, neutralizing bacterial toxins, and maintaining balanced oral pH[13]. Their natural antimicrobial action reduces bacterial growth, lowering the risk of dental caries, periodontal disease, and promoting overall oral health. Consequently, integrating charcoal toothbrushes into daily oral hygiene routines can be a valuable step toward achieving a brighter smile and optimal dental wellness.

This study introduces a novel approach using 3-in-1 herbal toothbrushes alongside charcoal toothbrushes to assess plaque index, highlighting their potential in enhancing oral hygiene. The present study demonstrated that all 3 brushes effectively reduced the plaque index and gingival bleeding index, indicating their potential in enhancing oral hygiene. The present study demonstrated that all 3 brushes effectively reduced the plaque index and gingival bleeding index, indicating their potential benefits in maintaining oral hygiene.

However, the charcoal toothbrush showed superior efficacy in reducing plaque compared to the 3in1 herbal toothbrush, aligning with the findings of the study conducted by Srihari Janakira et al[14]. This enhanced plaque

control may be attributed to the unique properties of charcoal, such as its natural antibacterial and adsorptive capabilities, which help in removing plaque and toxins more efficiently. Charcoal's slightly abrasive texture also aids in better mechanical cleaning of the tooth surface without being overly harsh on the enamel.

On the other hand, the 3-in-1 herbal-infused toothbrushes, recognized for their traditional medicinal properties, exhibited significant anti-inflammatory and antimicrobial effects, contributing to a notable reduction in gingival bleeding. These findings are consistent with the study by Darshana Gothane et al.,[15]which attributed these therapeutic effects to active compounds such as nimbidin and azadirachtin, known for their efficacy in combating oral pathogens and alleviating inflammation. Despite these advantages, the mechanical plaque removal capability appears to be less efficient compared to charcoal, which may explain the observed differences in plaque index reduction between the two types of brushes.

The findings of this study, consistent with those reported by Shwetal Somnathe et al.,[16] underscore the importance of toothbrush selection in oral health management. While both 3-in-1 herbal-infused toothbrushes and charcoal toothbrushes offer distinct benefits, the superior plaque control provided by charcoal toothbrushes suggests they may be particularly advantageous for individuals prone to plaque buildup.

Further research with larger sample sizes and longer follow-up periods could provide more comprehensive insights into the long-term effectiveness of these toothbrush types and their role in preventing periodontal diseases.

VI. Conclusion

Within the limitations, after 30 days of the trialthe study results concluded that, among the three types of toothbrushes, the charcoal-infused toothbrush bristles showed the most effective reduction in gingival bleeding and plaque. Thereforecharcoal-infused toothbrush bristles may be preferred for improved oral hygiene and antimicrobial effectiveness. However further studies focusing on the general population or individuals with specific periodontal issues should be taken into account with a larger sample size and microbial analysis of the toothbrush bristles for effective understanding.

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