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Evaluation of Toothbrushing Techniques Using the Modified Bass Technique Algorithm

Dr. Yuki Tanaka[1], and Dr. Maria Lopez[2]

[1,2]*Kyoto University Hospital, Kyoto, Japan*

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Abstract

To prevent gum disease, periodontal disease, and tooth decay, it is essential to maintain good oral hygiene. There are several ways to brush your teeth, but the Modified Bass Technique (MBT) is widely regarded as the gold standard for removing plaque from the gum line and beyond. However, people still struggle to execute it consistently due to its complexity. To compare the efficacy of MBT with that of conventional brushing techniques, this research proposes a combined clinical and algorithmic methodology. Fifty preclinical dentistry students were separated into two groups: one that received MBT and another that received a control. After 28 days, the students included in the trial were followed up. After completing structured training, participants in the MBT group underwent clinical evaluations, as well as assessments utilizing a rule-based approach that incorporated video analysis and a Random Forest classifier. The results demonstrated that the MBT group experienced significantly lower ratings for plaque and gingival bleeding ($p < 0.01$), especially in areas between the two joints. Scores for method adherence reported by the algorithmic evaluation were consistent with those of clinical examiners. To improve oral hygiene practices and provide objective assessment models for brushing technique quality, these findings advocate the use of structured MBT training and algorithmic feedback.

Keywords: Modified Bass Technique, Toothbrushing Evaluation, Oral Hygiene, Dental Plaque, Algorithmic Assessment, Random Forest Classifier, Gingival Health.

1 INTRODUCTION

A person's overall health includes their oral and dental hygiene. One of the best methods to promote and maintain optimal oral health is to practice good oral hygiene, which involves keeping your teeth and gums clean (Chen & Chu, 2019), (Saarela et al., 2021), (Axelsson & Lindhe, 1978). If you want to safeguard your oral and dental health from cavities and plaque for the long haul, the simplest thing you can do is brush your teeth twice a day. When it comes to controlling dental plaque, research has shown that proper brushing practices are more critical than using specific brushing equipment (Raviteja et al., 2017), (Grimaldi et al., 2021). There are various brushing techniques available, but the effectiveness of these techniques in removing plaque varies significantly. For this reason, finding the best method for dental cleanliness requires a systematic comparison of approaches. For its efficacy in reducing plaque formation and cleaning the gum line, the Modified Bass Technique (MBT) has garnered attention (Poyato-Ferrera et al., 2003). The complexity, nevertheless, makes it hard for people to properly accept it in the absence of adequate guidance or criticism. Some of the methods used to brush teeth include

the following: Stillman's, Charters, Bass, Modified Bass, Fones, Leonard, Scrub, and Roll or Modified Stillman. The results showed that the Modified Bass technique, the Horizontal Scrub technique, and the Fones technique were the three most successful brushing methods (Schlueter et al., 2010). The rationale behind this was that, compared to other methods, modified Bass and horizontal scrub significantly reduced gingival inflammation and improved plaque management. These results, however, were derived from a tiny sample size and very brief follow-up times.

Additionally, compared to standard tooth brushing methods, the Modified Bass technique was found to be more effective in decreasing supragingival plaque (Fjeld et al., 2017), (Patil & Kashetty, 2014). Using the Modified Bass technique while manually brushing your teeth is the most effective way to remove plaque and protect your oral tissues from mechanical damage (Sharma et al., 2010). Brushing techniques are evaluated in this study using an algorithm that considers accuracy, technique adherence, and plaque reduction. This algorithm ensures that the assessments are consistent and objective (Baruah et al., 2017). This method enables a more quantifiable and repeatable evaluation for different people. To that end, this research will employ an algorithm based on the Modified Bass Technique to assess and contrast various popular brushing approaches. The study also aims to evaluate the effectiveness of these strategies when provided with organized instruction, in terms of both performance and comprehension.

Key Contribution

- Created a framework for evaluating the Modified Bass Toothbrushing Technique that combines clinical data with algorithmic analysis.
- Compared MBT with conventional brushing techniques in a 28-day follow-up study with preclinical dentistry students.
- Used brushing video data to evaluate MBT adherence using a rule-based algorithm and a Random Forest classifier.
- The MBT group showed significantly better ratings for gingival bleeding and plaque than the control group.
- By comparing the algorithmic evaluation system's output with examiner observations, we validated its dependability.

The following is the paper's structure: The significance of efficient toothbrushing methods and the rationale for algorithm-based assessment are explained in the introduction. The literature review examines current brushing techniques and highlights gaps in digital evaluations. Data gathering, algorithm development, clinical protocol adherence, and participant selection are all detailed in the process. In the results and discussion section, we can find the study's quantitative outcomes and an analysis of the MBT technique's clinical and algorithmic success. The report concludes with a discussion of future study directions and a summary of the findings.

2 LITERATURE SURVEY

Research has demonstrated that frequent brushing and cleaning of the surrounding surfaces can successfully reduce dental plaque, which in turn prevents caries, gingivitis, and other disorders caused by plaque (Ratcliff, 1999), (Akcalı & Lang, 2018). Bass, Rolling, and many more brushing styles have emerged throughout the last half-century (Ganss et al., 2018), (Gibson & Wade, 2013). While several well-known techniques can be employed to clean the buccolingual and, to a lesser degree, the occlusal surfaces including the Horizontal Scrub, Fones, Leonard, Stillman, Charters, Bass, rolling stroke (press roll), and Smith-Bell the gingival sulcus can only be cleaned using the Bass technique (Nassar et al., 2013). Three methods of brushing are most popular among the general public: horizontal scrubbing, Fones, and vertical brushing (Leonard's technique) (Smutkeeree et al., 2011). However, despite its apparent difficulty, the modified Bass technique (MBT) is frequently recommended.

Some studies have found that other techniques, such as fones, horizontal scrub, charters, and stillman, are more effective than the bass or modified bass technique (MBT). Bass and horizontal scrub were not significantly different, according to Robinson et al. (1976) (Robinson, 1976). Although there was a lack of data and considerable variation among the studies considered, a recent meta-analysis (Janakiram et al., 2018) found that the modified Bass technique was more effective at removing plaque than the scrub toothbrushing techniques (Janakiram et al., 2018).

There appears to be a universal agreement that the bass technique is effective for cleaning the sulcus and subgingival areas; however, no single tooth brushing technique effectively cleans the occlusal pits, fissures, and interproximal areas of the teeth (Baruah et al., 2017). A study conducted by Honkala et al. (2015) examined the habits of 20 different countries in Europe and North America from 1994 to 2010. The results showed that most countries observed a generally positive trend, with people brushing their teeth twice a day. Interestingly, the study found that younger age groups had the most potential to improve their oral hygiene through oral health education. Oginni et al. (2013) found that among undergraduates at Obafemi Awolowo University, 73% brushed their teeth no more than once a day, and this is in keeping with the mostly descriptive nature of local research on brushing procedures (Harnacke et al., 2016). In addition, 52% of participants brushed vertically (up and down), 37% horizontally (side to side), and 11% in a circular motion, according to the study. In our setting, there is a dearth of randomized controlled trials that examine the efficacy of different brushing methods for plaque removal. (Jepsen et al., 2011), Poyato-Ferrera et al., 2003), (Arai & Kinoshita, 1977), (Lakshmi & Sakthivel, 2023).

We set out to conduct our study among dental students because of the crucial role they will play in the future as oral health care providers. They need to learn about various brushing techniques so they can educate the public about the importance of good oral hygiene. New digital dental equipment based on algorithms and artificial intelligence can assess brushing methods (Oginni, 2013), (Mahmoudi & Lailypour, 2015), (Kappagantula & Mannayee, 2024). There has been some success in developing

systems that can recognize patterns, angles, and sequence adherence in brushing utilizing video analysis (e.g., OpenCV), smart toothbrush sensors, and machine learning models (e.g., Random Forest or CNNs). Compared to traditional methods of manual observation, these instruments provide assessments that are objective and reproducible (Quigley & Hein, 1962), (Yaacob et al., 2014). This study fills a gap by integrating clinical and algorithmic evaluation, as there has been limited research that utilizes both methods to assess the Modified Bass Technique (Zendehboudi, 2014). Therefore, this study's overarching goal is to evaluate the modified bass approach in comparison to other tooth brushing methods in terms of their effectiveness in removing plaque (Honkala et al., 2015), (Hagberg et al., 2007).

3 METHODOLOGY

The Dental Centre at University College Hospital hosted a 28-day follow-up research in January and February 2019. The institutional review board gave its stamp of approval.

Participants

Students enrolled in the second year of preclinical dentistry at the University of Ibadan who had not yet entered clinical practice were eligible to participate in the study. Consequently, they were unprepared for the clinical aspects of dentistry, such as periodontics and community dentistry, on which they had not attended any lectures.

If a participant had any type of dental prosthesis, including orthodontic equipment or dentures, that crowded their teeth, had fewer than six natural teeth in each quadrant, or had periodontal pockets larger than 4 mm, they were not allowed to participate. Before participating in the study, participants were asked to provide informed consent.

Sample Size

The formula for typical comparative studies, as reported by Kirkwood et al. (2003), was used to compute the sample size, with Zα = 1.96 (5% significance level) and ZỤ = 0.84 (80% power). Giri et al. (2018) served as the basis for the means and standard deviations. It was determined that 25 participants per group was the minimum required sample size after accounting for a 7.5% attrition rate.

Randomization

Through the use of simple balloting, participants were randomly assigned to one of two groups. Selecting "Yes" meant you would be part of the Modified Bass Technique (MBT) group; selecting "No" meant you would keep brushing the way you usually would.

Flow Diagram

From recruitment through randomization into two groups (MBT vs. the previous technique) and follow-up completion, the movement of the research population is summarized in Figure 1. While the control group only received conventional evaluation, the MBT group also received algorithm-based

evaluation based on videos of brushing sessions. This setup highlights how the intervention group selectively utilized the algorithmic adherence score.

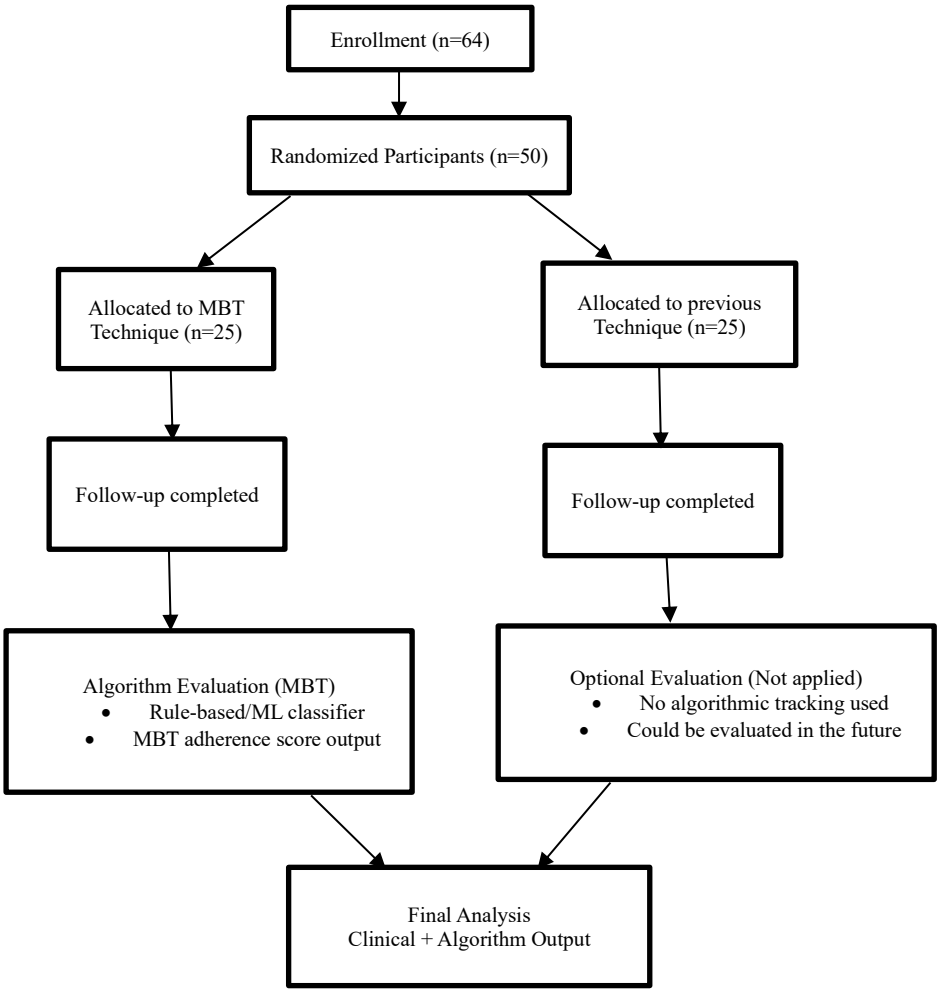

Figure 1: Flowchart of participant enrollment, allocation, follow-up, and algorithm evaluation process.

Blinding

The participants could not be made to forget which brushing technique was given to them. Nevertheless, the group allocations were not revealed to the examiners or data analysts.

Data Collection

A semi-structured questionnaire was used to gather data, which included questions about socio-demographics, oral health habits, and knowledge of brushing techniques. Oral examinations were administered by two examiners who had been calibrated (kappa = 0.89). The following tools were used to assess dental hygiene: •

The Simplified Oral Hygiene Index (OHI-S) (Greene et al., 1964)

Ainamo and Bay's Gingival Bleeding Index; Turesky's Adjustment to the Quigley-Hein Plaque Index

Algorithm-Based Evaluation

An algorithmic system was created to evaluate participants' adherence to the Modified Bass Technique, in addition to clinical scoring. A mobile camera was used to record each participant's brushing session. The video of the brushing was evaluated using critical MBT criteria by a rule-based algorithm developed in Python and implemented in OpenCV:

Short, horizontal vibratory strokes, a delicate sweeping motion from the gum to the tooth edge, the time spent per quadrant, and a posterior-to-anterior brushing sequence are all part of good dental hygiene.

The MBT adherence score was derived by scoring each parameter on a scale from 0 to 100.

With the use of annotated video examples marked as "Correct MBT" or "Incorrect Technique," a Random Forest machine learning classifier was trained in the expanded configuration. The model provided a confidence level for the proper technique detection and classified test films. The accuracy of the algorithm was confirmed by comparing its results with those of the examiners.

Architecture Diagram

A thorough examination and assessment of toothbrushing processes is guaranteed by the six functional layers that comprise the suggested design. Videos of participants' brushing sessions and the data input by any related sensors are collected by the Input Layer. After that, the Monitoring Layer is responsible for documenting the brushing process, which can be done automatically using motion-tracking sensors or manually by taking pictures with a camera. Crucial brushing characteristics, including bristle angle, stroke direction, brushing time, and quadrant coverage, are extracted and improved upon in the Processing Layer. Whether the brushing technique follows the Modified Bass Technique is determined by a rule-based system or a machine learning model (like Random Forest) in the Algorithm Layer, which receives this data. The Evaluation Layer then compares the algorithm's output to clinical plaque and gingival bleeding scores to ensure consistency in the results. The Output Layer culminates with a report that incorporates the algorithmic evaluation alongside the clinical outcomes. A strong foundation for assessing the efficacy of brushing is provided by this layered design, which permits both quantitative analysis and qualitative insights.

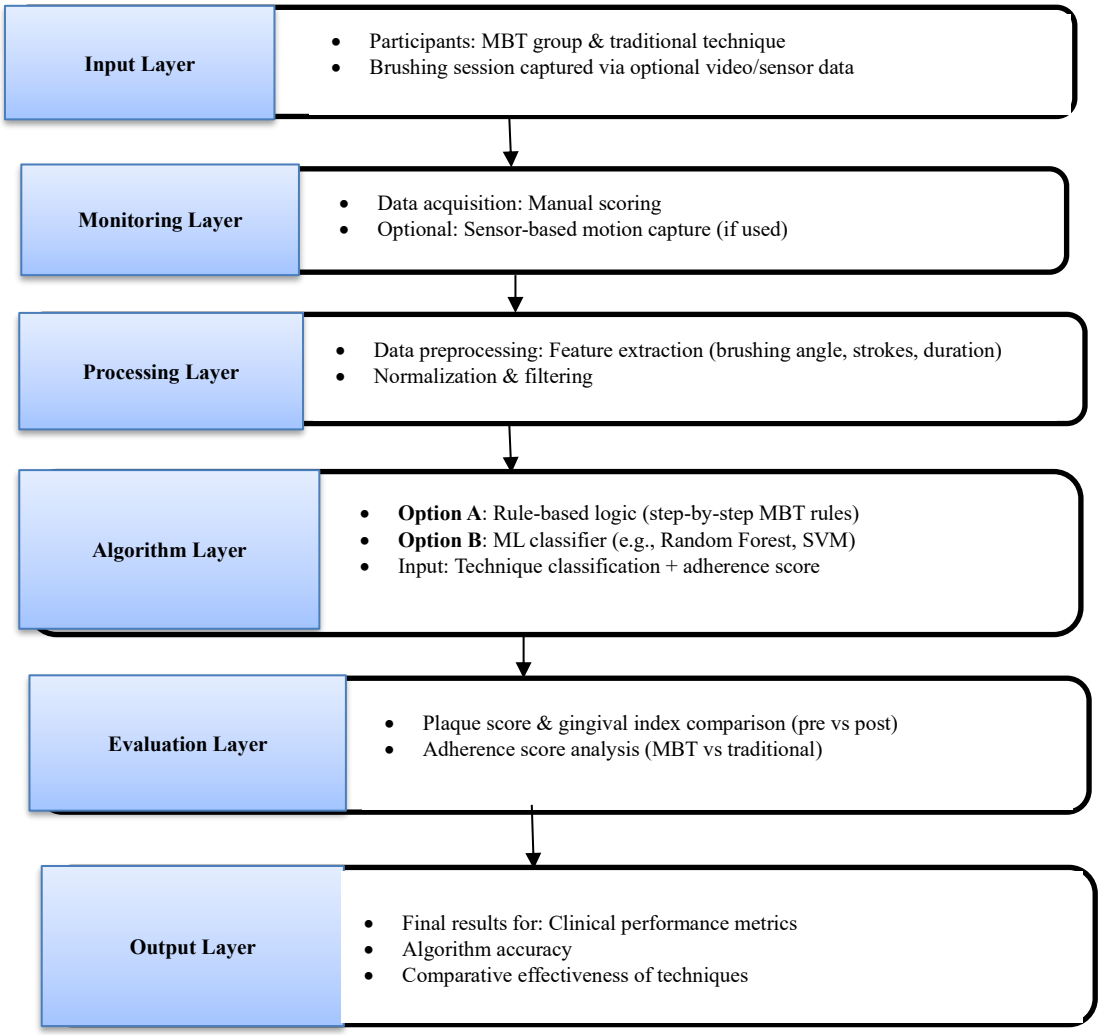

Figure 2: Architecture of the Modified Bass Technique Evaluation Algorithm System

Procedure

Fluoridated toothpaste and medium-textured toothbrushes were provided to all participants in the study. They were told to avoid any other techniques of plaque control and to brush for five minutes

twice a day, before breakfast and after dinner.

Before the trial began, all participants were requested to refrain from brushing their teeth or using any other oral hygiene products for at least 48 hours. All individuals also had preventative scaling and polishing. The plaque was seen using plaque-disclosing tablets. Blue staining showed older plaque (>12 hours), while red staining indicated recent plaque (<12 hours).

Except for third molars, scores for plaque and bleeding were recorded on four surfaces per tooth: mesial, distal, buccal/facial, and lingual/palatal. To get the total percentage values, the scores were averaged.

Before engaging in hands-on practice, the MBT group underwent standardized video-based training and live demonstrations with dental models.

Data Analysis

The mean ± SD ratings for gingival bleeding and plaque were used. All surfaces—face, interproximal, and full mouth—were given a score. Results at the beginning, after 7 days, and after 28 days were compared within groups using paired t-tests. A significance level of $p < 0.05$ was used.

4 RESULT AND DISCUSSION

4.1 Results

Plaque Score Analysis

After 28 days, plaque scores on all surfaces were lower in the group that used the Modified Bass Technique (MBT) as compared to the one that used the regular brushing method. In Table 1, the results are summarized.

Table :. Mean Plaque Scores Across All Surfaces, Buccal/Lingual, and Interproximal Areas

Examination	Region	Traditional Technique (Mean ± SD)	Proposed Model (MBT) (Mean ± SD)	Significance
Baseline	All Surfaces	33.07 (10.39)	37.43 (14.25)	–
	Buccal & Lingual	38.57 (15.31)	44.64 (17.07)	–
	Interproximal	27.57 (18.60)	30.21 (17.33)	–
7th Day	All Surfaces	28.14	29.24*	$p < 0.01$
	Buccal & Lingual	31.43	32.71*	$p < 0.01$
	Interproximal	24.85	25.78*	$p < 0.01$
28th Day	All Surfaces	23.64	21.19*	$p < 0.01$
	Buccal & Lingual	27.07	23.14*	$p < 0.01$
	Interproximal	20.21	19.23*	$p < 0.01$

At both the baseline and follow-up, a notable difference was observed in the MBT group compared to the traditional approach ($p < 0.01$). Statistically substantial improvements were observed in all locations, particularly buccal, lingual, and interproximal, in the MBT group ($p < 0.01$). On day 28, the control group had a mean plaque score of 23.64, and the MBT group had a score of 21.19 across all surfaces. With a decrease from 30.21 to 19.23, the interproximal surface exhibited the most significant improvement in the MBT group.

Gingival Bleeding Score Analysis

Table 2 shows that during the 28 days, there was a significant decrease in the gingival bleeding scores in the MBT group. A less dramatic shift occurred in the conventional brushing group, although they too demonstrated improvement.

Table 2: Mean Gingival Bleeding Scores for All Surfaces

Examination	Traditional Technique (Mean ± SD)	Proposed Model (MBT) (Mean ± SD)	Significance
Baseline	6.99 (5.32)	6.96 (5.24)	–
7th Day	6.14^	5.71*	$p < 0.05$ (MBT only)
28th Day	4.93**	4.03**	**p** < 0.01 (both groups)

No statistically significant difference is shown by a caret (^) when the p-value is more than 0.05; a statistically significant difference is indicated by a single asterisk (*) when the p-value is less than 0.05; and an extremely substantial difference is indicated by a double asterisk (**) when the p-value is less than 0.01.

Although the two groups began with comparable bleeding scores, by Day 7, only the MBT group had shown a significant improvement ($p < 0.05$). The MBT group exhibited a better gingival response (4.03 vs. 4.93) and both groups showed improvement by Day 28; however, the MBT group experienced a more noticeable reduction.

Algorithmic Evaluation

An additional evaluation was conducted on the MBT group using a rule-based method that was created in Python using OpenCV. The model used four MBT criteria—bristle angle, stroke motion, brushing sequence, and quadrant timing—to evaluate films of brushing. The MBT adherence score was assigned to each participant on a scale from 0 to 100. Strong compliance and correct technique were indicated by most scores exceeding 80.

In order to distinguish between the right and wrong MBT techniques, a Random Forest machine learning classifier was developed using labelled video samples. Classifier output was highly concordant with expert examiner rates, indicating that algorithmic evaluation can assist with remote monitoring of oral hygiene and provide trustworthy insights into brushing performance.

4.2 Discussion

Results show that the Modified Bass Technique outperforms conventional brushing techniques when taught methodically and backed by algorithmic evaluation for dental hygiene. Plaque and gingival bleeding scores improved significantly in the MBT group, especially in the interproximal areas that are often neglected when brushing horizontally or vertically.

This study's unique selling point is the way it combines clinical measurement with digital algorithm scoring to create a hybrid evaluation technique. A machine learning classifier and rule-based analysis work together to make brushing behavior monitoring more objective and possible in real-time or from a distance. Such systems could be useful in situations when there is a lack of caregiver supervision or self-monitoring, such as in pediatric oral health programs, geriatric settings, or home care.

Janakiram et al., (2018) and Baruah et al., (2017) also found that MBT is better at controlling plaque, and our data confirm that, when done properly and regularly, it is even better. When combined with current manual evaluation methods, the digital component makes them more precise and scalable.

Having said that, there are certain limitations to this study. Fifty preclinical dentistry students, who are at a high risk of not having adequate health literacy, made up the sample. Another possible source of bias in the comparison was the fact that algorithmic evaluation was only applied to the MBT group.

Increased sample size, evaluation of long-term adherence, and use of integrated sensors to provide real-time feedback during brushing should all be part of future research.

5 CONCLUSION AND FUTURE WORK

When taught with organized assistance and evaluated using an algorithmic approach, the Modified Bass Technique significantly improves oral hygiene outcomes compared to typical brushing procedures, according to this study's findings. Greater plaque reduction and enhanced gingival health were observed in participants trained in MBT, particularly in problematic locations like interproximal surfaces. Brushing behavior assessment was further confirmed by integrating a rule-based system with a machine learning model, which provided an objective and scalable way to evaluate method adherence.

Applying this algorithmic framework to a wider and more diverse population, such as those who do not have oral health issues and those who are at high risk, such youngsters or the elderly, should be the focus of future research. Improved user compliance and support for tailored oral hygiene instruction can be achieved through the integration of real-time brushing sensors, mobile feedback systems, and long-term follow-up. Improving classification accuracy and making it easier to integrate into smart toothbrushes or everyday smartphone apps are two additional benefits of augmenting the machine learning model with more annotated data.

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