Investigating the ability of electric and manual toothbrushes in eliminating dental plaque from human teeth

Biology Extended Essay

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ABSTRACT

The aim of this extended essay is to investigate and compare the effect of electric and manual brushes on the amount of dental plaque. The research question is ***"What is the effectiveness of electric and manual toothbrushes in terms of their cleaning effect of dental plaque on the human teeth by measuring the dental plaque indexes of the people with the age range of 20-50 who don't have periodontal diseases and no more than 4 teeth loss."***

It is hypothesized that there will be a significant difference between the electric toothbrushes and manual toothbrushes in terms of their cleaning effect of dental plaque on the human teeth.

To investigate the effect of dental plaque cleaning of electric and manual toothbrushes, the values of plaque indexes were examined with the help of a three-stage measurement. The first stage was the measurement of the dental plaque index without changing the experimental group's brushing habits. The second dental plaque index was at the end of the first week with participants brushing their teeth with the given toothbrushes and toothpastes. The final dental plaque index measurement was end of the third week.

After applying the Friedman Test to the data acquired from the 3-stage dental plaque measurement, it was concluded that the usage of both electric and manual toothbrushes eliminated the dental plaque on the tooth surface between measurements. According to Mann-Whitney Test, the usage of electric brushes is more effective in eliminating dental plaque.

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I. INTRODUCTION

Dental plaque is also called microbial plaque, oral biofilm, dental biofilm. It is highly organized diverse microbial communities attached to the surface of hard tooth tissues[1].

Plaque is referred to as a "biofilm" by scientists because it is a population of living bacteria surrounded by a gluey polymer covering. The sticky covering aids microbe attachment to surfaces in mouth, allowing them to flourish into thriving microcolonies. One gram of plaque (wet weight) contains approximately 10^{11} bacteria. With the use of highly sensitive molecular techniques for microbial identification, it has been estimated that more than 500 distinct microbial phylotypes can be present as natural inhibitants of dental plaque. Any individual may harbor 150 or more species.

Dental plaque is a sticky film of bacteria that constantly forms on teeth. It is made up of food particles. Dental plaque is the mixture of dental bacteria with sugary and starchy foods or drinks. Such as; milk, fruit juice, soft drinks, bread, pasta… etc.[2].

Everyone has dental plaque to some degree but brushing and flossing habits, consuming sugary foods and drinks, smoking, using medications are some factors that affect the amount of formation of dental plaque.

If the teeth are not brushed properly after meals, dental plaque begins to form and build up on the teeth. If dental plaque piles up on the teeth and is not removed by brushing and floss, it can cause tooth decay and loss, gum disease called ***gingivitis,*** severe gum infection called ***periodontitis,*** tooth infection called ***abscessed tooth*** and tartar build up[3].

Gingivitis that is associated with dental plaque formation is the most common form of gingival disease. Plaque-induced gingival disease is the result of an interaction between the

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[1]Digel, Ilya, et al. "Dental Plaque Removal by Ultrasonic Toothbrushes." Us National Library of Medicine, 23 Mar. 2020,

[2]Stanborough, Rebecca Joy. "What Is Dental Plaque." *Healthline*, 2 Aug. 2019,

[3] Asadoorian J. CDHA Position Paper on Tooth Brushing. CJDH. 2006; 40(5): 232-248.

microorganisms found in the dental plaque biofilm and the tissues and inflammatory cells of the host. The primary cause of gingival inflammation is bacterial plaque.

Brushing the teeth regularly, flossing daily, using mouthwash, choosing healthy foods, seeing the dentist regularly reduces the formation of dental plaque.

Microbial biofilm growth occurs within hours, and must be completely removed at least once every 48 hours. in the experimental setting with periodontally healthy subjects to prevent inflammation[4]. The American Dental Association (ADA) recommends that individuals brush twice per day and use floss or other interdental cleaners once per day to effectively remove microbial plaque and prevent gingivitis[5]. Daily plaque biofilm control permits each patient to assume responsibility for oral health every day. Without it, optimal periodontal health cannot be achieved. So, the dental plaque is the major cause of periodontal disease and the elimination of the dental plaque is the most important and almost the only way of achieving it.

Dental plaque index is used to evaluate the level and rate of plaque formation on tooth surfaces, and to test the efficacy of oral care products for removal and prevention of plaque deposits from these surfaces. The method I will be using in my experiment to visualize the dental plaque will be rinsing the mouth with a revealing solution (e.g., % erythrosine), which makes the plaque red. Oral care products contain active agents formulated specifically to prevent dental diseases such as caries and gingivitis[6].

Research question: What is the effectiveness of electric and manual toothbrushes in terms of their cleaning effect of dental plaque on the human teeth by <u>measuring the dental plaque indexes</u> of the people with the age range of 20-50 who don't have periodontal diseases and no more than 4 teeth loss.

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[4] Straub AM, Salvi GE, Lang NP: Supragingival plaque formation in the human dentition. In Lang NP, Attstrom R, Löe H, editors: Proceedings of the European Workshop on mechanical plaque control, Chicago, 1998, quintessence.

[5] American Academy of Periodontology: Position paper: guidelines for periodontal therapy. J Periodontol 72:1624, 2001.

[6] Andrew Joiner, in Handbook for Cleaning/Decontamination of Surfaces, 2007

II. HYPOTHESIS

Rechargeable electric toothbrushes head both oscillates and rotates which means they are expected to break up and remove more plaque compared to manual toothbrushes[7]. Electric toothbrushes provide the movement which is faster than a person can provide with his/her own hands. Users only need to guide the electric toothbrush in the mouth[8].

The efficiency of manual toothbrushes is determined by abilities, proper brushing technique, and adequate application time. Individuals who lack hand manipulation for any reason (physical impairment or competence) will brush less effectively using a manual toothbrush. When brushing with manual and electric toothbrushes for the same period of time is compared in terms of bristle impact on the tooth surface, electric brushes are deemed superior to manual brushes.

The variables that cannot be controlled in this study include the subjects' dietary habits (sugar and carbohydrate diets) and their present toothbrushing ability. A three-stage measurement will be used to minimize the effect of dietary effects on the dependent variable. The three-stage measurement will assess the difference between the initial and subsequent measurements. To reduce the effect of the individual's brushing ability on the dependent variable, all participants will receive a practical and written proper toothbrushing guidance including the time period of the brushing and the brushing technique at their first visit to the dental clinic.

It is hypothesized that there will be a significant difference between the electric toothbrushes and manual toothbrushes in terms of their cleaning effect of dental plaque on the human teeth. It is expected that using electric toothbrush will be more efficient to clean the dental plaque.

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[7] "The Sonic Toothbrush- What You Need to Know." Sydney Holistic Dental Centre, www.shdc.com.au/general-dentistry/sonic-toothbrush-what-you-need-to-know. Accessed 11 May 2021.

[8] Norris, Taylor. "Is It Better to Use an Electric or a Manual Toothbrush?" Healthline, 8 Mar. 2019, www.healthline.com/health/dental-and-oral-health/electric-toothbrush-vs-manual.

III. METHOD DEVELOPMENT AND PLANNING

To develop an appropriate method for this study. I spoke with several dentists and conducted research on scholarly literature concerning dental plaque, the mechanisms of electric toothbrushes, and manual toothbrushes. I also carried studies on various diets and studied their effects on the production of dental plaque.

The first issue I encountered was deciding which experiment group to use in my investigation. In my conversations with dentists, I found that there shouldn't be a lot of tooth loss in the mouth to be able to measure the dental plaque index properly. As a result, I limited my experiment to those who had lost no more than four teeth. I also narrowed the age range to 20-50 because periodontal disorders tend to increase with age and also eliminate ethical issues of 18-under people participating to the experiment. The reason why 20 is chosen as lower bound is to ensure toothbrushing discipline. Distribution of male and female participants will be adjusted equally to eliminate the gender factor.

The second issue was choosing the toothbrushes I am going to use in my experiment. 25 **Oral-B Pro-Flex Clinic Line manual toothbrushes** and **Ipana Pro-Expert Sensitive Protection toothpaste** will be provided to a group of 25 people. **Oral-B vitality 100 rechargeable electric toothbrushes[9] [10]** and **Ipana Pro-Expert Sensitive Protection toothpaste** will be provided to another group of 25. I choose Oral-B vitality 100 rechargeable electric toothbrush to use in my study because according to my research, the Oral-B vitality 100 rechargeable electric toothbrush is a good daily toothbrush with good plaque removal. As shown in the official website of Oral-B, the following are the features of this toothbrush: A toothbrush is required for daily cleaning. Removes more plaque than a standard manual toothbrush. Vibrates every 30 seconds to notify the brushed area that it needs to be changed.

After giving the toothbrushes to the experimental group, they will be asked to brush their teeth twice a day. Each person of the experimental group will have a toothbrushing report card and they will be asked to fill in the report after each brushing. The group which are brushing their

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[9] "Oral-B Vitality 100 Cross Action." *Oral-B*, www.oralb.com.tr/tr-tr/urunler/sarjli-dis-fircalari/oral-b-vitality-100-beyaz-sarj-edilebilir-eis-fircasi. Accessed 24 Sept. 2021.

[10] "USING A RECHARGEABLE ELECTRIC TOOTHBRUSH." Oral-B, oralb.com/en-us/oral-health/solutions/electric-toothbrushes/using-a-rechargeable-electric-toothbrush. Accessed 5 May 2021.

teeth with electric toothbrushes will be called group "E". The group which are using manual toothbrush will be called group "M".

The experiment is going to last a total of three weeks. From the consultations with the dentists, I learned that periodontal observation is usually done at the end of the third week. Which means a minimum of three weeks is necessary to observe the changes. In light of this information, I decided to do the experiment for three weeks long.

Three stage measurement will be done to measure the plaque indexes and periodontal indexes of the selected experimental group. Measurements are going to be taken at a private dental clinic by me with the supervision of a dentist. The first measurement will be measuring the plaque indexes and periodontal indexes of everyone who are involved in the experiment without changing their brushing habits. The second stage plaque index and periodontal index measurement will be at the end of 1st week with them using the given toothbrushes and given toothpastes. From my researches and consultations, I learned that change in brushing habits usually is being able to observed at the end of the first week, so the 1st measurement after changing people's brushing habits will be at the end of the 1st week. The third measurement is going to be taken at the end of the 3rd week to finalize the experiment.

IV. MATERIALS

1) Curaprox plaque disclosing agent
2) Drinking water
3) Hand mirror
4) 50 people who meet the specified criteria
5) Gloves
6) Surgical Mask
7) 25× Electric tooth brush – Oral B Vitality 100
8) 25× Manual tooth brush – Oral B Pro-Flex Clinic Line
9) 50× toothpaste – Ipana Pro-Expert Sensitive Protection
10) camera

V. METHOD

1) Before applying the plaque disclosing agents, photos of the entire mouth were taken to demonstrate the difference between time points and to inform the patients, as plaque is not always evident to patients.

2) Every patient was instructed to chew one tablet of Curaprox plaque disclosing agent (Curaplast, Switzerland) for 30 seconds before wiping their teeth with their tongue and rinsing their mouth with water to remove any excess solution. Plaque on the teeth is stained by the tablet.

3) The tablet stains the mature plaque blue and the new plaque red. The color of the staining is critical. Red staining denotes places that the patient forgets to clean on occasion, while blue staining suggests areas that the patient forgets to clean on a regular basis.

4) Following staining, full mouth photos were taken again, and plaque scores were calculated using the Plaque Index by Silness J, Löe H[11]. This index is the most commonly used index in dentistry and periodontal research studies to determine and evaluate plaque. According to this index, the periodontal probe is held at a 30-degree angle to the long axis of the tooth and moved around the gingiva-to-tooth link. And the plaque is graded in accordance with;

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[11] Silness J, Löe H. Periodontal disease in pregnancy II-correlation between oral hygiene and periodontal condition. Acta Odontol Scand 22:121-135,1964.

It is an index for evaluating dental plaque. Evaluation is made by moving the periodontal probe inside the gum pocket and on the tooth surface. The use of dental plaque staining solutions facilitates the assessment. According to this index[12];

0: there is no dental plaque in the gum area

1: There is dental plaque in the form of a film attached to the free gum edge or to the area adjacent to the tooth

2: There is visible dental plaque accumulation in the gum pocket, on the edge of the gum, and on the adjacent tooth surface.

3: There is abundant dental plaque deposits in the gum pocket, on the edge of the gum, and on the adjacent tooth surface.

5) According to the index, each tooth has score for plaque (0,1,2,3). Total score for a patient is calculated by adding all scores together and dividing them by the number of teeth that the patient has.

6) After the photos and plaque scores were taken, the patients were given a hand mirror to enable them see the staining areas in order to improve their dental hygiene and awareness. They were informed and shown how to clean certain places based on the color of the staining.

11) Following the initial visit and assessment, patients were divided into two groups at random. During the experiment, one group used the Oral B Vitality 100 rechargeable electric toothbrush, while the other used the Oral B Pro-Flex Clinic Line manual tooth brush. Both groups used the same Ipana Pro-Expert Sensitive Protection toothpaste. At the end of each visit, patients brushed and flossed thoroughly to remove all staining.

12) All of these procedures were repeated one week and three weeks after the initial visit.

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[12] Silness J, Löe H. Periodontal disease in pregnancy II-correlation between oral hygiene and periodontal condition. Acta Odontol Scand 22:121-135,1964.

VI. RESULTS

Table 1: The raw data table shows the initial dental plaque index values, the dental plaque index values after 1 week brushing with electric toothbrush, the dental plaque index values after 3 weeks with brushing electrical toothbrush, and the mean dental plaque index values of the maxilla (upper jaw) and mandibula (lower jaw).

PI: Plaque index

ELECTRICAL TOOTHBRUSH PI

Sample #	Initial Maxilla	Initial Mandibula	Initial Mean	I Week Maxilla	I Week Mandibula	I Week Mean	III Week Maxilla	III Week Mandibula	III Week Mean
1	2,93	3,00	2,97	0,64	0,79	0,71	0,29	0,29	0,29
2	3,00	2,86	2,93	0,71	0,64	0,68	0,29	0,36	0,33
3	2,07	2,43	2,25	0,79	0,86	0,83	0,36	0,29	0,33
4	1,86	2,00	1,93	0,93	0,79	0,86	0,29	0,21	0,25
5	3,00	2,98	2,99	0,64	0,86	0,75	0,36	0,29	0,33
6	2,64	2,36	2,50	0,57	0,71	0,64	0,36	0,36	0,36
7	2,86	2,93	2,90	0,64	0,79	0,72	0,29	0,29	0,29
8	2,43	2,64	2,54	0,50	0,86	0,68	0,36	0,43	0,40
9	3,00	2,43	2,72	1,14	0,93	1,04	0,43	0,36	0,40
10	2,14	2,64	2,39	0,64	0,79	0,72	0,29	0,29	0,29
11	1,71	1,86	1,79	0,50	0,86	0,68	0,21	0,14	0,18
12	3,00	3,00	3,00	1,14	0,93	1,04	0,43	0,50	0,47
13	2,43	2,64	2,54	0,79	0,86	0,83	0,29	0,21	0,25
14	2,64	2,79	2,72	0,71	0,64	0,68	0,29	0,29	0,29
15	3,00	2,79	2,90	0,93	0,79	0,86	0,36	0,36	0,36
16	2,50	3,00	2,75	0,86	0,71	0,79	0,43	0,36	0,40
17	2,79	2,93	2,86	0,64	0,71	0,68	0,28	0,36	0,32
18	1,71	2,14	1,93	0,86	1,07	0,97	0,14	0,21	0,18
19	3,00	2,79	2,90	0,79	0,86	0,83	0,36	0,29	0,33
20	2,43	1,86	2,15	0,64	0,71	0,68	0,29	0,21	0,25
21	2,86	2,79	2,83	0,93	0,64	0,79	0,21	0,29	0,25
22	2,93	2,86	2,90	0,50	0,86	0,68	0,29	0,29	0,29
23	3,00	2,64	2,82	1,36	1,07	1,22	0,43	0,36	0,40
24	2,93	2,86	2,90	0,50	0,86	0,68	0,29	0,29	0,29
25	2,07	2,43	2,25	0,79	0,64	0,72	0,21	0,14	0,18

Table 2: The raw data table shows the initial dental plaque index values, the dental plaque index values after 1 week brushing with manual toothbrush, the dental plaque index values after 3 weeks with brushing manual toothbrush, and the mean dental plaque index values of the maxilla (upper jaw) and mandibula (lower jaw).

PI: Plaque index

MANUAL TOOTHBRUSH PI									
	Initial			I Week			III Week		
Sample #	Maxilla	Mandibula	Mean	Maxilla	Mandibula	Mean	Maxilla	Mandibula	Mean
1	2,93	3,00	2,97	1,00	0,92	0,96	1,00	1,00	1,00
2	2,86	2,86	2,86	1,07	1,14	1,11	1,00	1,14	1,07
3	2,64	2,86	2,75	1,64	1,57	1,61	1,07	1,00	1,04
4	3,00	2,93	2,97	1,36	1,36	1,36	1,29	1,00	1,15
5	2,79	2,64	2,72	1,00	1,14	1,07	1,00	0,93	0,97
6	2,43	2,07	2,25	1,07	1,36	1,22	1,21	1,07	1,14
7	2,50	2,64	2,57	1,36	1,29	1,33	0,93	1,00	0,97
8	2,21	2,43	2,32	1,57	1,64	1,61	1,14	1,07	1,11
9	2,79	2,79	2,79	1,21	1,07	1,14	0,93	1,14	1,04
10	2,86	2,71	2,79	1,36	1,57	1,47	1,21	1,14	1,18
11	2,50	2,64	2,57	1,29	1,29	1,29	1,00	1,07	1,04
12	3,00	2,93	2,97	1,57	1,36	1,47	1,29	1,07	1,18
13	2,07	2,21	2,14	1,36	1,57	1,47	0,93	0,86	0,90
14	2,43	2,64	2,54	1,07	1,36	1,22	1,14	1,00	1,07
15	2,93	2,71	2,82	1,21	1,57	1,39	1,00	1,00	1,00
16	2,64	2,36	2,50	1,29	1,64	1,47	0,93	1,07	1,00
17	1,71	2,14	1,93	1,29	1,64	1,47	0,86	1,00	0,93
18	2,79	2,07	2,43	1,57	1,57	1,57	1,07	1,00	1,04
19	2,64	2,50	2,57	1,64	1,36	1,50	0,93	1,14	1,04
20	2,43	2,21	2,32	1,57	1,29	1,43	0,86	1,14	1,00
21	2,93	3,00	2,97	1,36	1,36	1,36	1,00	1,07	1,04
22	2,64	2,64	2,64	1,57	1,64	1,61	1,14	0,93	1,04
23	2,43	2,50	2,47	1,00	1,29	1,15	1,07	1,00	1,04
24	2,79	2,36	2,58	1,36	1,29	1,33	1,21	1,14	1,18
25	2,71	2,79	2,75	1,57	1,14	1,36	1,21	1,14	1,18

VII. DATA ANALYSIS

Data analysis is done by the "SPSS" program.

Table 3: The table shows the mean values, confidence interval for mean and standard deviation of the dental plaque indexes of the initial measurement, first measurement and the final measurements.

	Toothbrush			Statistic	Std. Error
Initial	Electrical Toothbrush	Mean		2,6144	,07400
		95% Confidence Interval for Mean	Lower Bound	2,4617	
			Upper Bound	2,7671	
		Std. Deviation		,37000	
	Manual Toothbrush	Mean		2,6076	,05474
		95% Confidence Interval for Mean	Lower Bound	2,4946	
			Upper Bound	2,7206	
		Std. Deviation		,27368	
I Week	Electrical Toothbrush	Mean		,7904	,02884
		95% Confidence Interval for Mean	Lower Bound	,7309	
			Upper Bound	,8499	
		Std. Deviation		,14418	
	Manual Toothbrush	Mean		1,3588	,03565
		95% Confidence Interval for Mean	Lower Bound	1,2852	
			Upper Bound	1,4324	
		Std. Deviation		,17824	
III week	Electrical Toothbrush	Mean		,3084	,01484
		95% Confidence Interval for Mean	Lower Bound	,2778	
			Upper Bound	,3390	
		Std. Deviation		,07420	
	Manual Toothbrush	Mean		1,0540	,01582
		95% Confidence Interval for Mean	Lower Bound	1,0213	
			Upper Bound	1,0867	
		Std. Deviation		,07911	

Table 4: The results of the Test of Normality made with the SPSS program

	Toothbrush	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Initial	Electrical	,212	25	,005	,858	25	,002
	Manual	,099	25	,200*	,950	25	,245
I Week	Electrical	,207	25	,007	,817	25	,000
	Manual	,134	25	,200*	,951	25	,270
III Week	Electrical	,122	25	,200*	,956	25	,338
	Manual	,210	25	,006	,926	25	,070

The "Shapiro-Wilk" test of goodness of fit" was applied for the normality test. The normality hypothesis was rejected since the P value was lower than 0.05 so, it is not normally distributed
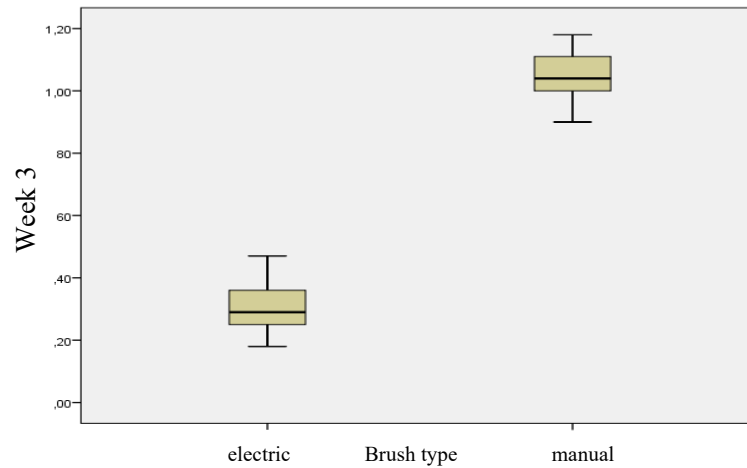
Graph 1: Box and whisker Plot showing the 1st 2nd and 3rd quartiles of the initial measurements
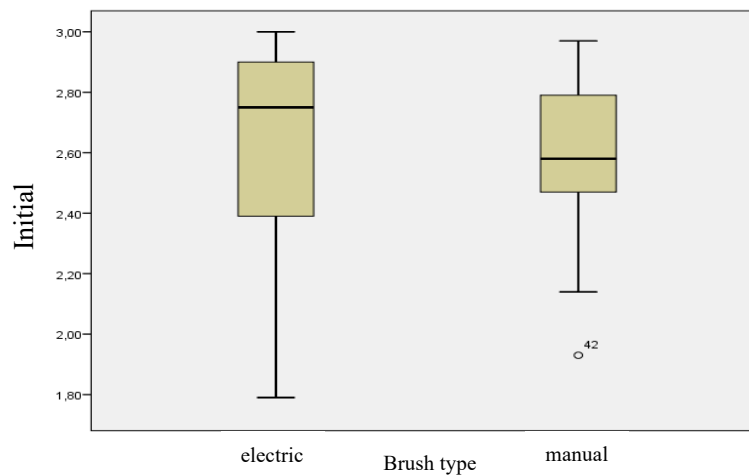
Graph 2: Box and whisker Plot showing the 1st 2nd and 3rd quartiles of the week 1 measurements
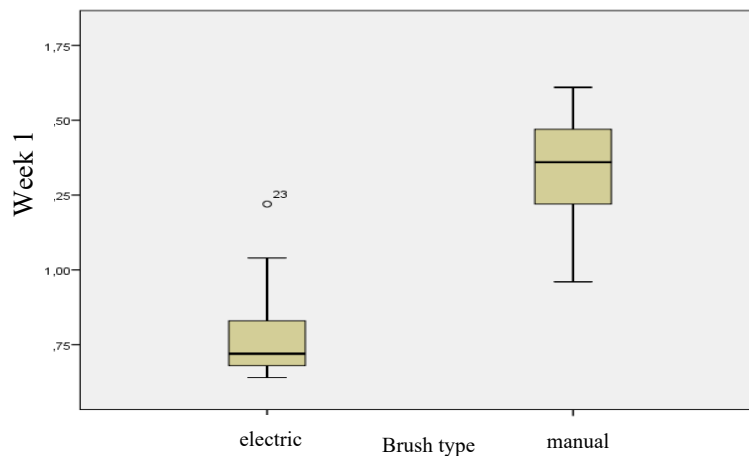
Graph 3: Box and whisker Plot showing the 1st 2nd and 3rd quartiles of the week 3 measurements

Table 5: The results of the Test of Homogeneity of Variance made with the SPSS program.

Test of Homogeneity of Variance		Levene Statistic	df1	df2	Sig.
Initial	Based on Mean	3,457	1	48	,069
I Week	Based on Mean	1,339	1	48	,253
III Week	Based on Mean	,076	1	48	,784

For variance homogeneity, the "Levene" test was utilized. The P value was greater than 0.05 as a result of the test, and the hypothesis that the variances of the groups were homogeneous was accepted.

The normality tests indicated that the data didn't show normal distribution, so the non-parametric Friedman test was used. For repeated measurements with more than two measurement values, the Friedman test is utilized.

Table 6: The results of Non-Parametric Friedman Test for electrical toothbrush

Test Statistics[a,b]	
N	25
Chi-Square	50,000
df	2
Asymp. Sig.	,000

The P value for the electrical toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination through measurements.

a. Toothbrush = Electrical

b. Friedman Test

Table 7: The results of Non-Parametric Friedman Test for manual toothbrush

Test Statistics[a,b]	
N	25
Chi-Square	48,080
df	2
Asymp. Sig.	,000

The P value for the manual toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination through measurements.

a. Toothbrush = Manual

b. Friedman Test

Table 8: Descriptive Statistics for Electrical Toothbrush

Descriptive Statistics for Electrical Toothbrush					
	N	Mean	Std. Deviation	Minimum	Maximum
Initial	25	2,6144	,37000	1,79	3,00
I Week	25	,7904	,14418	,64	1,22

Table 9: Descriptive Statistics for Manual Toothbrush

Descriptive Statistics for Manual Toothbrush					
	N	Mean	Std. Deviation	Minimum	Maximum
Initial	25	2,6076	,27368	1,93	2,97
I Week	25	1,3588	,17824	,96	1,61

Table 10: Wilcoxon Signed Ranks Test of electrical toothbrush between I week and initial measurement

Test Statistics[a,b]	
	I Week - Initial
Z	-4,374[c]
Asymp. Sig. (2-tailed)	,000

The P value for the electrical toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination between the initial and 1st measurements.

a. Toothbrush = Electrical

b. Wilcoxon Signed Ranks Test

Table 11: Wilcoxon Signed Ranks Test of manual toothbrush between I week and initial measurement

Test Statistics[a,b]	
	I Week - Initial
Z	-4,374[c]
Asymp. Sig. (2-tailed)	,000

The P value for the manual toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination between the initial and 1st week measurements.

a. Toothbrush = Manual

b. Wilcoxon Signed Ranks Test

Table 12: Descriptive Statistics for electrical toothbrush

Descriptive Statistics for electrical toothbrush					
	N	Mean	Std. Deviation	Minimum	Maximum
Initial	25	2,6144	,37000	1,79	3,00
III Week	25	,3084	,07420	,18	,47

Table 13: Descriptive Statistics for manual toothbrush

Descriptive Statistics for manual toothbrush					
	N	Mean	Std. Deviation	Minimum	Maximum
Initial	25	2,6076	,27368	1,93	2,97
III Week	25	1,0540	,07911	,90	1,18

Table 14: Wilcoxon Signed Ranks Test of electrical toothbrush between III week and initial measurement

Test Statistics[a,b]	
	III week - Initial
Z	-4,374[c]
Asymp. Sig. (2-tailed)	,000

a. Toothbrush = Elektirkli

b. Wilcoxon Signed Ranks Test

The P value for the electrical toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination between the initial and 1st week measurements.

Table 15: Wilcoxon Signed Ranks Test of manual toothbrush between III week and initial measurement

Test Statistics[a,b]	
	III Week - Initial
Z	-4,373[c]
Asymp. Sig. (2-tailed)	,000

a. Toothbrush = Manual

b. Wilcoxon Signed Ranks Test

The P value for the manual toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination between the initial and 3rd week measurements.

Table 16: Descriptive Statistics for electrical toothbrush

Descriptive Statistics for electrical toothbrush					
	N	Mean	Std. Deviation	Minimum	Maximum
I Week	25	,7904	,14418	,64	1,22
III Week	25	,3084	,07420	,18	,47

Table 17: Descriptive Statistics for manual toothbrush

Descriptive Statistics for manual toothbrush					
	N	Mean	Std. Deviation	Minimum	Maximum
I Week	25	1,3588	,17824	,96	1,61
III Week	25	1,0540	,07911	,90	1,18

Table 18: Wilcoxon Signed Ranks Test of electrical toothbrush between III week and I week measurement

Test Statistics[a,b]	
	III Week- I Week
Z	-4,378[c]
Asymp. Sig. (2-tailed)	,000

The P value for the electrical toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination between the 3rd and 1st week measurements.

a. Toothbrush = Electrical

b. Wilcoxon Signed Ranks Test

Table 19: Wilcoxon Signed Ranks Test of manual toothbrush between III week and I week measurement

Test Statistics[a,b]	
	III Week- I Week
Z	-4,334[c]
Asymp. Sig. (2-tailed)	,000

The P value for the manual toothbrush is lower than the critical value 0,05. Which means there is a significant difference in the dental plaque elimination between the 3rd and 1st week measurements.

a. Toothbrush = Manual

b. Wilcoxon Signed Ranks Test

Table 19: Mann-Whitney Test Statistics comparing the dental plaque elimination of electrical and manual toothbrushes

Mann-Whitney Test Statistics			
	Initial	I week	III Week
Mann-Whitney U	283,500	9,000	,000
Wilcoxon W	608,500	334,000	325,000
Z	-,564	-5,907	-6,089
Asymp. Sig. (2-tailed)	,573	,000	,000

a. Grouping Variable: Toothbrush type

When the variables were grouped by brush type, the P value was 0.573 which is greater than 0.05, indicating that there was no significant difference in the initial measurement. The absence of a significant difference in the initial measurement is an estimated result, given the initial measurement was taken prior to changing people's brushing habits. Because the P values for

the first- and third-week measurements were approximately 0.000 which is less than 0.05, it was determined that there was a significant difference in dental plaque elimination between the electric and manual toothbrushes.

To determine which type of toothbrush shows better performance in terms of dental plaque elimination from the tooth surface, the average dental plaque index values in *Table 3* and their changes over weeks should be compared.

Table 21: Dental plaque index over weeks

Descriptive				
	Toothbrush		Statistic	Std. Error
Initial	Electrical Toothbrush	Mean	2,6144	,07400
	Manual Toothbrush	Mean	2,6076	,05474
I Week	Electrical Toothbrush	Mean	,7904	,02884
	Manual Toothbrush	Mean	1,3588	,03565
III week	Electrical Toothbrush	Mean	,3084	,01484
	Manual Toothbrush	Mean	1,0540	,01582

Table 22: Changes of dental plaque index over weeks

	Toothbrush	Difference of mean dental plaque index	
Initial- I Week	Electrical Toothbrush	2,6144 − 0,7904	1,824
	Manual Toothbrush	2,6076 − 1,3588	1,2488
I Week- III week	Electrical Toothbrush	0,7904 − 0,3084	0,482
	Manual Toothbrush	1,3588 − 1,0540	0,3048
Initial- III week	Electrical Toothbrush	2,6144 − 0,3084	2,306
	Manual Toothbrush	2,6076 − 1,0540	1,5536

As demonstrated by the data in *Table 22*, the electrical toothbrush is more effective in eliminating dental plaque from the tooth surface. Each time a comparison is made (Initial- I

Week, I Week- III week, Initial- III week), the amount of dental plaque eliminated is greater with electrical toothbrush.

Graph 4: Dental Plaque Index through initial measurement, week 1, week 3 of manual and electric toothbrush
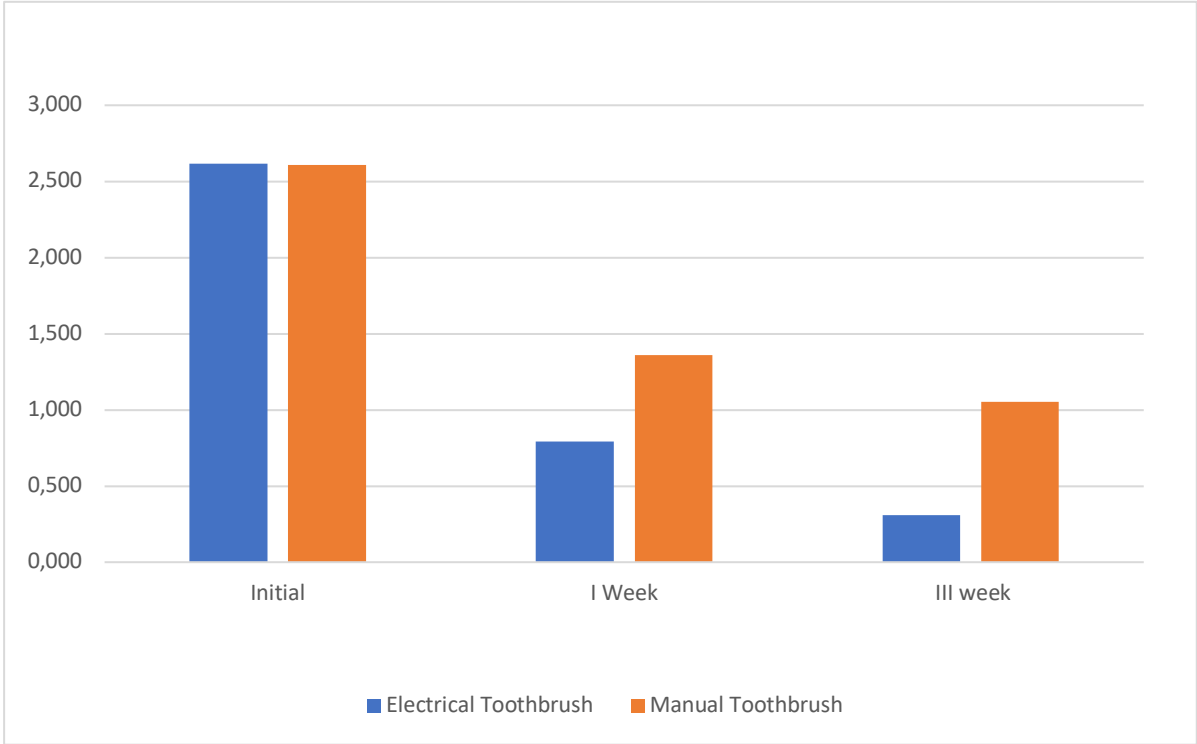
VIII. CONCLUSION AND EVALUATION

The aim of this experiment was to investigate and compare the cleaning effects of electric and manual brushes on the amount of dental plaque. Electrical toothbrushes, it was hypothesized, would be more effective than manual toothbrushes in eliminating dental plaque from the surface of human teeth.

In this experiment, people between the age range of 20 and 50 who had not lost more than four teeth were randomly assigned to one of two groups. Group "E" used an electric toothbrush to brush their teeth according to the time and guidelines set. Group "M" used a manual toothbrush to brush their teeth according to the time and guidelines stated. The experiment lasted a total of three weeks and a three-stage measurement procedure was used. The dental plaque measurements taken at the beginning of the study, at the conclusion of the first week, and at the end of the third week. Plaque scores were calculated using the Plaque Index by Silness J, Löe H[13].

This study poses no risk to the environment because no hazardous substances or applications were used. This study presents no ethical issues because the experiment participants volunteered to participate. At the start of the experiment, participants signed a consent form indicating that they volunteered to participate.

Following the collection of data, the "Shapiro-Wilk" test of goodness of fit and the "normality test" were performed. After conducting this test, it was determined that, because the P value of initial value of electrical toothbrush was 0.002 which is lower than 0.05, the normality hypothesis was rejected, which means the data did not display a normal distribution. Because the data did not show a normal distribution, the non-parametric Friedman test was used. According to the non-parametric Friedman test, there is a significant difference in the cleaning effect of electric and manual toothbrushes on dental plaque between each measurement. As a result of Mann-Whitney statistical test, the P values of I- week and III-week measurements was .000 which is lower than the alpha value 0.05. As a result, the null hypothesis is rejected, and the alternative hypothesis, saying that there is a substantial difference between the groups in

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[13] Silness J, Löe H. Periodontal disease in pregnancy II-correlation between oral hygiene and periodontal condition. Acta Odontol Scand 22:121-135,1964.

terms of their cleaning impact of dental plaque, is accepted. The statistical test results support the main hypothesis that "electric toothbrushes are more efficient than manual toothbrushes in eliminating dental plaque from the surface of human teeth."

To appropriately calculate and compare the dental plaque index, it was determined that the experimental group should be between the ages of 20 and 50, because the likelihood of periodontal diseases increases with age. Furthermore, it was ensured that the participants have no more than 4 tooth loss. To set up a reliable experiment and a reliable data collecting method, identical electrical and manual toothbrushes were given to the two experimental groups. The toothpastes were controlled in order to eliminate the toothpaste factor.

Despite the fact that many fine details were taken into account when planning the experiment, some systematic errors could not be avoided. The first of these is people's ability to brush their teeth. The right brushing technique was explained and demonstrated to all participants at the beginning of the experiment, however it is possible that some people brushed better and more thoroughly than others. Secondly, the participants were asked to brush their teeth twice a day, and at the end of each brushing, they were asked to mark on the form distributed at the start of the experiment, but it was noticed at the end of the experiment that some participants skipped some brushing days, even if only slightly. Because it is a small numerical value, this minor systematic error has been tolerated.

Although it is not a systematic error, the motivation factor is also an error factor that can affect the result in this experiment. The group that received electric brushes may have been more driven to brush their teeth with an electric toothbrush, which was different from their regular toothbrushing routine, and so may have brushed more carefully.

To increase the reliability and precision of this experiment, measurements could be taken with digital dental imaging instruments and the change in plaque amount could be analyzed by overlaying these measurements.

The relationship between plaque index and periodontal health was also comparable, but because the experiment's duration was determined to be 3 weeks, it was eliminated from the evaluation because the change in periodontal health could not be observed such short time period. In longer plaque index follow-ups, the gingival index and periodontal index readings can be compared.

My research question at the beginning of this study was, "Is there a significant difference between the dental plaque cleaning effects of electrical and manual toothbrushes from the surface of human teeth?" is responded in favor, indicating that there is a statistical difference in the effects of these toothbrushes.

A prior study, *"Efficacy of sonic versus manual toothbrushing following professional mechanical plaque removal: A 6-month randomized clinical experiment,[14]"* concluded that sonic toothbrushes were more effective in removing dental plaque than manual toothbrushes. The findings of this study[15], which I obtained at after conducting a literature review, support the findings of my investigation.

According to the findings of this study, using an electric toothbrush is more effective in eliminating dental plaque from the tooth surface. At the conclusion of this study, another question for future research arises: how do electric and manual toothbrushes effect periodontal health, specifically formation of gingivitis?

[14] Mensi M, Scotti E, Sordillo A, Brognoli V, Paola Dominici M, Calza S. Efficacy of sonic versus manual toothbrushing after professional mechanical plaque removal: A 6-month randomized clinical trial. *Int J Dent Hygiene*. 2021;19:366–375

[15] Mensi M, Scotti E, Sordillo A, Brognoli V, Paola Dominici M, Calza S. Efficacy of sonic versus manual toothbrushing after professional mechanical plaque removal: A 6-month randomized clinical trial. *Int J Dent Hygiene*. 2021;19:366–375

IX. APPENDICES

APPENDIX I

ELECTRICAL TOOTHBRUSH INITIAL MEASUREMENT FOR AN INDIVIDUAL

ELECTRICAL TOOTHBRUSH WEEK I MEASUREMENT FOR AN INDIVIDUAL

ELECTRICAL TOOTHBRUSH WEEK III MEASUREMENT FOR AN INDIVIDUAL

MANUAL TOOTHBRUSH INITIAL MEASUREMENT FOR AN INDIVIDUAL

MANUAL TOOTHBRUSH WEEK I MEASUREMENT FOR AN INDIVIDUAL

MANUAL TOOTHBRUSH WEEK III MEASUREMENT FOR AN INDIVIDUAL

APPENDIX II

Plaque Index by Silness J, Löe H[16].

a. Plak indeksi: Hastanın ağız hijyeni durumunu ortaya koymak amacıyla alınmaktadır.

öntem: Periodontal sonda dişin uzun aksına yaklaşık 30 derecelik bir açıyla tutularak, diş-işeti birleşiminde diş yüzeyinde gezdirilir.

Plak indeksi (Pİ)(Silness&Löe-1964)

0	Plak yok	
1	Dişeti kenarında ince bir plak film tabakası izlenmektedir. Bu oluşum Ancak sonda yardımı ile belirlenmektedir.	
2	Dişeti kenarında orta derecede bir plak film tabakası izlenmektedir. Aproksimal alanda plak yok.Göz ile belirlenebilir seviyede.	
3	Dişeti kenarında oldukça fazla bir plak film tabakası izlenmektedir. İnterdental alanlar plak ile doludur.	

b. Gingival indeks (GI, Silness&Löe 1963-1967): Bu indeks sistemi 1963 yılında Silness ve Löe tarafından 1963 yılında geliştirilmiş, 1967 de ise çeşitli araştırıcılar tarafından modifiye edilmiştir. Sistemde inflamasyonun en temel bulgusu olan kanama değerlendirilir. Dişlerin mesial, distal, vestibül, lingual dişetleri, dişetindeki inflamasyon, ödem renk değişikliği ve kanama durumuna göre değerler verilerek değerlendirilir. Daha sonra bu değerler toplanır ve dörde bölünür. Bu şekilde gingival indeks hesaplanır. Değerlerin toplamı diş sayısına bölünürse kişiye ait skor elde edilmiş olur.

0	Sağlıklı dişeti, inflamasyon yok
1	Dişetinde hafif inflamasyon, renk değişikliği ve hafif ödem var, sondalamada kanama yok
2	Dişetinde orta derecede inflamasyon, ödem ve kırmızık var, sondalamada kanama mevcut
3	Dişetinde ileri derecede inflamasyon, ödem ve kırmızılık var, spontan kanama mevcut.

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[16] Silness J, Löe H. Periodontal disease in pregnancy II-correlation between oral hygiene and periodontal condition. Acta Odontol Scand 22:121-135,1964.

APPENDIX III

Oral B Vitality 100 electric toothbrush agent   **Curaprox plaque disclosing**

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