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The Change in Oral Microorganisms in Orthodontic Patients depending on the Use of Waterpiks

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Abstract

Background/Objectives: The study was conducted to examine how the combined use of Waterpiks and hexamidine mouthwash by orthodontic patients impacts the decrease of oral periodontal pathogens and the dental plaque index(PHP Index).

Methods/Statistical analysis: The study conducted oral health education for four weeks by dividing 30 orthodontic patients at Y dental clinic in Busanjin-gu, Busan into a control group(Waterpiks, hexamidine) and an experimental group(Waterpiks + hexamidine) after which their change in oral microorganisms was measured.

Findings The oral microbial count decreased the most when the number of weeks of Waterpik use was longer and when there was a combined use of Waterpiks and hexamidine after administering oral health education.

Improvements/Applications: Oral health education hours must be extended so that dental hygienists can encourage patients to use a Waterpik and a hexamidine solution in combination.

***Keywords*:** Orthodontic, Oral microbial count, Chlorhexidine, Waterpik, PHP index

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1. Introduction

Involving the correction of an irregular set of teeth and malocclusion, orthodontic treatment has been implemented with the purpose of improving occlusion up to the present point, but recently people have grown in interest[1] in the aesthetics of the treatment so that the demand for orthodontic treatment has increased with an aim at improving the arrangement of the teeth and the aesthetics of the face in addition to improving occlusion. However, although the treatment is helpful, it carries a very high incidence rate for periodontal disease in the area around the orthodontic device[2], and according to research, causes temporary changes to the gums without permanent damage to the periodontium during the treatment process by the device[3]. The most effective method of dental plaque removal is tooth brushing[4]. However, as tooth brushing alone removes only about 42% of dental plaque inside the mouth[5], it's desirable to carry out tooth brushing through the use of supplementary oral hygiene products according to the oral health status of each individual[6]. In general, patients using an orthodontic device are recommended to use an electric toothbrush[7] which can clean the tooth surface around the orthodontic brackets, along with floss and an interdental brush which can prevent gingivitis by cleaning the area around the brackets, the orthodontic bands, and the gap between the teeth[8]. In particular, orthodontic patients must mount a complex device inside their mouth for a long period of time, and the mobility resulting from tooth migration can cause gingival enlargement or gingivitis. Hence, it is necessary to promote the

keratinization of the epithelial cells within the tooth surface and gingival sulcus and plan for the cleaning and management of the gap between teeth by using supplementary oral hygiene products[9].

There are not enough preceding studies on how the change in oral microorganisms through the use of Waterpiks[9] and hexamidine[10] impacts the tissue surrounding the teeth. Hence, the present study observed the change in microbial count in each group of subjects when hexamidine mouthwash and Waterpiks were used in combination during a 4-week oral health management program.

Therefore, the present study attempts to generate motivations capable of improving the oral hygiene of gingivitis and periodontal disease patients, not just orthodontic patients, and deal with the importance of educating the use of supplementary oral hygiene products when dental hygienists administer oral health education. Furthermore, the study is expected to be used as source data regarding a synergy effect between the reduction of periodontal pathogens and changes in dental plaque thanks to the combined use of Waterpiks and hexamidine mouthwash in addition to the altered oral hygiene management skills of the subjects.

2. Materials and Methods

2.1. *Materials*

The 30 subjects participating in the present study were orthodontic patients in their 20s and 30s at Y dental clinic in Busanjin-gu, Busan, who were divided into a control group(Waterpik, hexamidine) and an experimental group(Waterpik+hexamidine). After sufficiently explaining the research methods and purpose and administering a brief survey on topics such as the need for the research, the research purpose and methods, guaranteed anonymity for research participation, the voluntary nature of participation, consent and refusal, and the advantages and disadvantages that may occur, the survey was implemented upon acquiring the voluntary consent of the research subjects. The study was conducted with subjects visiting the clinic 3 times during the 4-week period, with the subjects selected on the basis of preceding studies.

2.2. *Methods*

The study was carried out by dividing the subjects into 3 groups – the control group, experimental group 1, which used the Waterpik, and experimental group 2, which used the Waterpik and hexamidine mouthwash in combination. The duration for wearing the orthopedic device was 1 to 2 years, and the appliance used – Clippy-C – was identical for everyone. The subjects in each group were told to clean their mouth with a Waterpik or through the combined use of a Waterpik and hexamidine mouthwash every day before they went to bed. They then exchanged feedback on their Waterpik use in the morning of the following day. After collecting bacteria inside the mouth at the start of the study, an oral health management program was implemented, and the subjects underwent the 1st session of the program before Waterpik use, an interim check two weeks later to determine whether oral health management was being effectively conducted, and a 2nd session two weeks later when the experiment ended, after which the subjects were again tested for changes in periodontal pathogens by being sampled for oral bacterial, with subjects undergoing the bacterial sampling and testing on the dental unit chair placed inside the dentist's office. Subjects who received pre-training(oral health management program) underwent bacterial collection by means of mouthwash, and changes in periodontal pathogens before and after the study were then compared.

2.2.1. waterpik, Hexamidine

The hexamidine is diluted and used together with the Waterpik. Twenty-five ml(0.1%) of hexamidine(28) is diluted with 225ml of water and then subjects rinsed their mouth using the solution. The Waterpik is used after tooth brushing and before going to bed. Food must not be eaten after using the Waterpik, and this is repeated once every day before going to bed for 4 weeks.

2.2.2. Oral Microorganism Testing(PCR)

The study used the PeriogenTM Perio Real Time PCR Kit (Microis, Korea) in order to carry out a quantitative analysis of the oral microorganisms within the collected samples. The components of the kit include 10cc of AnyGargle and a 50cc conical tube. The mouthwash solution is contained in the conical tube, and then the 50cc conical tube including the 10cc of mouth rinse(mouthwash) will be stored in cold storage until a request for analysis is made

2.2.3. Categorizing Periodontal Pathogens

The study used the PeriogenTM Perio Real Time PCR Kit (Microis, Korea) in order to carry out a quantitative analysis of the oral microorganisms within the collected samples. The components of the kit include 10cc of AnyGargle and a 50cc conical tube. The mouthwash solution is contained in the conical tube, and then the 50cc conical tube including the 10cc of mouth rinse(mouthwash) will be stored in cold storage until a request for analysis is made<Table 1>.

Table 1: Categorizing Peridontal Pathogens

Division		Periodontal Pathogen
High Risk Group	Red Complex	*Aggregatibacter actinomycetemcomitans* *Prophyromonas gingivalis* *Tennerella forsythensis* *Treponema denticola*
Medium Risk Group	Orange Complex	*Prevotella intermedia* *Fusobacterium nucleatum* *Pavimonas micra* *Campylobacter rectus* *Eubacterium nodatum* *Prevotella nigrescens*
Low Risk Group	Green Complex	*Eikenella corrodens*

2.3. *Analysis Method*

The study used SPSS(25.0 for windows), SPSS Inc. Chicago, IL. USA for data analysis and arrived at the conclusion that the study was statistically significant through significance testing at a significance level under 0.05. The 11 major bacterial species among the periodontal pathogens were divided into three groups—the high risk group, the medium risk group, and the low risk group—and the sum of the bacteria in each group was then converted into log values(Log 10^5) and digitized.

3. Results

3.1. General Characteristics of the Subjects

The analysis results of the study show that, in terms of general characteristics, 60.0%(18) of the subjects were ‘male’ and 40.0%(12) were ‘female’. In terms of age, 56.7%(17) were ’25 or younger’ and 43.3%(13) were ‘26 or older’. For educational background, 43.3%(13) had an education level of ‘junior college degree or lower’ and 56.7%(17) had an education level of ‘4-year university degree or higher’, while in terms of monthly average income, 40.0%(12) made ‘less than 3 millon KRW and 60.0(18) made 3 million KRW or more. In terms of occupation, most of the subjects 40.0%(12) were students, followed by 23.3%(7) who were ‘office/administrative workers’, 13.3%(4) who were ‘service/sales workers’, 13.3%(4) who were ‘miscellaneous workers’, and 10.0%(3) who were ‘professionals/technicians’. Most of the subjects,

93.3%(28), were 'unmarried', while 6.7%(2) were 'married'. <Table 2>.

Table 2: General Characteristics of the Subjects

Division		N(%)
Gender	Male Female	18(60.0) 12(40.0)
Age	~25 26~	17(56.7) 13(43.3)
Education Level	~Junio college degree 4 Year college degree~	13(43.3) 17(56.7)
Average Monthly Income	~3 million KRW 3 million KRW~	12(40.0) 18(60.0)
Occupation	Student Professional, Technician Service/Sales, Self-employed/Business Office/Administrative Miscellaneous	12(40.0) 3(10.0) 4(13.3) 7(23.3) 4(13.3)
Marital Status	Unmarried Married	28(93.3) 2(6.7)
Total		30(100.0%)

3.2. Change in quantity depending on the type of oral microorganism in the saliva according to each group.

Analysis into change in quantity depending on the type of oral microorganism in the saliva for the control group, Waterpik group, and Waterpik+hexamidine group, upon comparing pre-post test results, found that, for the red complex, Aa was higher in the post-test(5.36) than in the pre-test(4.00), Pg was higher in the post-test(0.64) than in the pre-test(0.62), but Td was lower in the post-test(2.00) than in the pre-test(5.16). For the orange complex, Pi was lower in the post-test(16.82) than in the pre-test(27.96), Fn was higher in the post-test(92.44) than in the pre-test(71.60), Cr was higher in the post-test(29.83) than in the pre-teset(24.48), Pm was higher in the post-test(21.17) than in the pre-test(20.41), En was lower in the post-test(11.98) than in the pre-test(24.18), and Pn was lower in the post-test(52.14) than in the pre-test(56.46). For the green complex, Ec was higher in the post-test(1.91) than in the pre-test(1.88).

Regarding the red complex in the Waterpik group, Aa was higher lower in the post-test(0.03) than in the pre-test(0.16), Pg was lower in the post-test(0.04) than in the pre-test(0.12), but Tf was higher in the post-test(1.61) than in the pre-test(0.31), Td was higher in the post-test(0.18) than in the pre-test(0.04). For the orange complex, Pi was higher in the post-test(20.03) than in the pre-test(16.36), Fn was higher in the post-test(33.09) than in the pre-test(19.38), Pm was higher in the post-test(13.84) than in the pre-test(3.36), Cr higher in the post-test(2.87) than in the pre-test(1.78), En was higher in the post-test(2.44) than in the pre-test(0.26), while in regard to the green complex, Ec was lower in the post-test(0.58) than in the pre-test(0.68).

With regard to the red complex in the Waterpik+hexamidine group, Pg was lower in the post-test(1.01) than in the pre-test(1.54), Tf was lower in the post-test(0.98) than in the pre-test(1.76), and Td was lower in the post-test(0.11) than in the pre-test(0.86), while in regard to the orange complex, Pi was

higher in the post-test(28.12) than in the pre-test(19.86), Fn was lower in the post-test(38.66) than in the pre-test(85.64), Pm was lower in the post-test(7.42) than in the pre-test(25.01), Cr was lower in the post-test(5.25) than in the pre-test(14.75), En was lower in the post-test(27.38) than in the pre-test(63.87) and Pn was lower in the post-test(18.03) than in the pre-test(34.53)<Table 3>.

Table 3: Change in quantity depending on the type of oral microorganism in the saliva according to each group

Division		Red			
Division	Bacteria	Aa	Pg	Tf	Td
Control Group	Pre Post t(p)	4.00±8.94 5.36±11.98 -1.00(.001)	0.62±1.38 0.64±1.42 -1.36(.001)	2.12±1.77 2.25±2.047 -0.158(.360)	5.16±9.06 2.44±2.73 0.913(.028)
Waterpik	Pre Post t(p)	0.16±0.42 0.03±0.07 1.000(.001)	0.12±0.03 0.04±0.09 -1.000(.001)	0.31±0.59 1.61±3.12 -1.144(.001)	0.04±0.06 0.18±0.27 -1.223(.685)
Waterpik+ Hexamidine	Pre Post t(p)	- - -	1.54±1.86 1.01±1.26 1.894(.001)	1.76±1.07 0.98±0.63 3.324(.015)	0.86±1.08 0.11±0.25 1.943(.024)

Division		Orange						Green
Division	Bacteria	Pi	Fn	Pm	Cr	En	Pn	Ec
Control Group	Pre Post t(p)	27.96±41.36 16.82±27.32 1.560(.005)	71.60±73.98 92.44±52.54 -1.430(.028)	20.41±20.20 21.17±17.48 -0.285(.010)	24.48±20.60 29.83±28.05 -0.666(.130)	24.18±49.61 11.98±17.70 0.790(.036)	56.46±72.89 52.14±59.93 0.302(.036)	1.88±1.33 1.91±1.45 -0.052(.276)
Waterpik	Pre Post t(p)	16.36±34.58 20.03±40.74 -1.304(.001)	19.38±28.86 33.09±25.44 -1.627(.131)	3.36±4.78 13.84±17.58 -1.782(.014)	1.78±2.79 2.87±4.50 -1.064(.034)	0.26±0.58 2.44±5.45 -1.000(.001)	-2.66±4.93 -	0.68±1.06 0.58±0.44 0.311(.025)
Waterpik + Hexamidine	Pre Post t(p)	19.86±24.52 28.12±51.09 -0.553(.078)	85.64±23.20 38.66±26.36 3.511(.652)	25.01±22.15 7.42±6.26 2.305(.061)	14.75±12.28 5.25±5.47 2.595(.070)	63.87±89.97 27.38±18.99 1.072(.120)	34.53±47.30 18.03±24.76 1.632(.001)	4.91±4.05 1.82±2.10 1.601(.838)

3.3. Pre-post changes in oral microorganisms in the saliva depending on the Waterpik use of each group.

Comparing changes in oral microbial count in the saliva, from the initial value to the point when management was terminated, for the control group, the Waterpik group, and the Waterpik+hexamidine group reveals, for the control group, a decrease in changes for the red complex and the orange complex from pre-test to post-test although these results were not statistically significant and an increase in changes for the green complex from pre-test to post-test although these results were not statistically significant. For the Waterpik group, there was an increase in changes for the red complex and the orange complex, from pre-test to post-test but a decrease in changes for the green complex from pre-test to post-test although the increase was not significant. For the Waterpik+hexamidine group, there was a significant decrease($p<0.05$), from 4.16 to 2.11, in the red complex, and a trend of decrease in the orange complex and the green complex although the decrease was not significant<Table 4>.

Table 4: Pre-post changes in oral microorganisms in the saliva depending on the Waterpik use of each group

Division		Bacteria		t-value[1)]
		Pre	Post	
Control Group	Red	11.89±13.17	10.69±15.71	-.275(.797)
	Orange	225.08±192.43	224.39±141.34	-.018(.986)
	Green	1.88±1.33	1.91±1.45	.052(.961)
Waterpik	Red	.55±.72	1.86±3.02	1.159(.311)
	Orange	41.14±70.60	74.92±83.32	2.572(.062)
	Green	.68±1.06	.58±.44	-.311(.771)
Waterpik+Hexamidine	Red	4.16±2.07	2.11±1.58	-4.609(.010)
	Orange	243.66±116.24	124.86±51.27	-2.134(.100)
	Green	4.91±4.05	1.82±2.10	-1.601(.185)

[1)] $p<.005$ by paired t -test

4. Discussion

The present study attempted to offer basic data in regard to effective oral management methods for patients with fixed orthodontic devices by analyzing changes in oral microorganisms and dental plaque, which result when managing oral hygiene through the mechanical method of Waterpiks and the chemical method of hexamidine for orthodontic patients. The most commonly occurring periodontal diseases in orthodontic patients are caused by gram-negative anaerobic bacteria, such as *P. intermedia, P. gingivalis, A. actinomycetemcomitans,* and *F. nucleatum*, which exist in subgingival dental plaque [11]. In order to reduce these bacteria, the present study identified how the combined use of a hexamidine solution and a Waterpik impacted bacterial count. The antibacterial effect of the hexamidine solution was excellent, but its long-term use reported side effects, specifically, the discoloration of the soft tissue and tooth surface [12]. Therefore, the study was conducted by using a diluted solution with a 0.01% concentration which does not cause any harm.

First, a summary of the research into changes in the quantity of oral microorganisms in the saliva by their type for each group revealed, for the red complex of the control group, an increase($p<0.05$) in Aa and Pg and a decrease($p<0.05$) in Td, whereas for the orange complex, there was an increase($p<0.05$) in Fn and Pm and a decrease($p<0.05$) in Pi, En, and Pn. For the red complex of the Waterpik group, there was an increase($p<0.05$) in Tf and a decrease($p<0.05$) in Aa and Pg. For the orange complex, there was an

increase($p<0.05$) in Pi, Pm, and En, while, for the red complex of the group that used Waterpiks and hexamidine in combination, there was a decrease($p<0.05$) in Pg, Tf, and Td, and for the orange complex, a decrease($p<0.05$) in Pn. The results were similar to the study by Eun-ji Lee [13], which reported a decrease in gram-negative anaerobic bacteria, such as *P. intermedia(Pi), P. gingivalis(Pg), A actinomucetemcomitans(Aa),* and *F. nucleatum(Fn)* in subgingival dental plaque, which cause periodontal disease inside the mouth. The results also matched with the study by Hye-ji Kim, which states that red complex bacteria with the strongest pathogenicity for oral periodontitis includes *P. gingivalis(Pg), T. denticola(Td),* and *Bacteroides forsythus*, followed by orange complex bacteria, specifically, *F. nucleatum(Fn) subspecies, P. intermedia(Pi), P. nigrescens(Pn),* and *Peptostreptococcus.* The study by Jin-su Kim[15] reported Waterpik use alleviated gingivitis and the effect was better when the duration of use was longer. This corresponded with the results of the present study, which reports a decrease in bacterial count with an increase in the number of days of Waterpik use. Furthermore, the results are similar to the study by Jeong-gu Kang[16], which reported a trend of decrease in cell activity when using a 0.001% concentration of chlorhexidine. Thus, although the exclusive effects of either Waterpiks or hexamidine were significant, the study determined a maximized effect experienced by the Waterpik+hexamidine group. Hence, the emergence of gram-negative anaerobic bacterial species closely related to periodontitis makes possible the assumption that the environment surrounding the brackets is gram-negative anaerobic, and that it is necessary to manage the tooth surface of orthodontic patients at a level similar to subgingival environments.

Second, the pre-post changes in the oral microbial count of each group show a decrease in some of the bacterial count post-test for red complex, orange complex, and green complex bacteria for the control group and the Waterpik group although the decrease was not significant, whereas the group that used Waterpiks and hexamidine in combination demonstrated a significant decrease in red complex bacteria in the post-test ($p<0.05$). Mi-ji Koo[17] reported an experimental group using a 0.12% chlorhexidine solution experienced a greater decrease in oral bacterial count than the control group using a saline solution. Eun-ju Nam[12] stated that the use of chlorhexidine resulted in a decrease in oral bacterial count post-test upon assessing oral microorganisms and that the evaluation index also displayed a trend of decrease. The study also corresponded to the results of the present study, which found a decrease in bacterial count upon assessing oral microorganisms.

The limitations of the present study involve the difficulty of examining the duration of Waterpik use by subjects who previously used Waterpiks prior to their participation in the study, and the difficulty of generalizing the results due to the small number of research subjects. The study has determined that subsequent studies require investigating the level of various improvements regarding the recruitment of research subjects and research procedures. Despite these limitations, the study concludes the need to identify supplementary oral hygiene products for periodontal disease prevention and oral hygiene management by comparing and proving the effects brought about by the exclusive or combined use of mechanical treatments, such as Waterpiks, and chemical treatments, such as hexamidine, in terms of periodontal disease management.

The periodontal disease incidence rate during orthodontic treatment is much higher than that experienced by general subjects undergoing other treatment, so subjects must be made aware of the need to use a Waterpik and a hexamidine solution in combination depending on who they are. They should be expected to personally use these products, and the hours of oral health education administered by dental hygienists on every regular checkup should be expanded for orthodontic patients in order to increase their rate of use.

5. Conclusion

The present study arrived at the following conclusions by administering the exclusive and combined use of Waterpiks and hexamidine through oral health education on 30 orthodontic patients at Y dental clinic in Busan in order to offer source data on effective oral health management methods for patients with orthodontic devices. This was achieved by analyzing changes in oral microbial counts when patients managed their oral hygiene either through the exclusive use of Waterpiks or the use of Waterpiks and hexamidine in combination.

The pre-post analysis into changes in the quantity of oral microorganisms by their type for each group found that for the red complex in the control group, Aa and Pg increased and Td decreased, while, for the orange group, Fn and Pm increased, and Pi, En, and Pn decreased. For the red complex in the Waterpik group, Tf increased, and Aa and Pg decreased, whereas, for the orange complex, Pi, Pm, and En increased, and, for the green complex, Ec decreased. For the red complex in the group using Waterpiks and hexamidine in combination, Pg, Tf, and Td decreased, and, for the orange complex, Pn decreased.

The pre-post changes in the total oral microbial count of red, orange, and green complexes showed a trend of some decrease post-test in red, orange, and green complexes for both the control group and the Waterpik group, but the decrease was not statistically significant. On the other hand, the study identified a greater decrease in the red complex post-test for the Waterpik+hexamidine group than it did in the control group and the Waterpik group.

The present study revealed the use of Waterpiks and hexamidine in combination led to a decrease in oral microbial count. Therefore, the study determined that opportunities for and the hours of oral health education during which dental hygienists can increase the level of understanding of orthodontic patients toward the combined use of Waterpiks and hexamidine should be expanded, and that regular inspections were necessary to enable their continuous use.

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