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Influence of different types of mouthwashes on force decay of elastomeric chain recommended in SARS-COV-2 pandemic

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Abstract

OBJECTIVES: This study aimed to compare the force decay of the power-chain elastics after exposure to anti-coronavirus 2019 (COVID-19) antiseptic mouthwashes at different intervals.

METHODS: A total of 300 power-chain pieces were used from American Orthodontics (AO) and Dentaurum (D) brands. Each piece composed of five loops that were selected to simulate canine retraction distally. The samples were randomly grouped according to immersion in the tested mouthwashes 0.2% povidone-iodine (PVP-I), 1% hydrogen peroxide (H_2O_2), and 0.2% chlorhexidine (CHX) and cetylpyridinium chloride (CPC). The maximum tensile load failure testing (MTLT) was assessed at six time points (zero, one hour, 24 hours, 1, 2 and 4 weeks). Analysis of variance (ANOVA) and Tukey's *post hoc* tests were used to analyse the data, where $P < 0.05$.

RESULTS: Significant differences in MTLT of power-chain elastics used at different immersion intervals were observed. MTLT, in each tested group, decreased significantly as the immersion time increased with significant differences among the tested mouthwashes at each time point. H_2O_2 group displays a maximum force decay throughout the time intervals for both brands, in contrast to CPC group, which shows less degradation over time.

CONCLUSION: Both brands are decade over time during exposure to the tested mouthwashes. CPC mouthwashes is a good option to be described for orthodontic patient during COVID-19 pandemic, whereas H_2O_2 mouthwashes should be avoided.

Keywords:

Antiseptic mouth washes, COVID-19, force decay, power chain elastics

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Respiratory disease that is caused by SARS-CoV-2 (COVID-19) virus infection, has converted to a major problem globally at 2020 inception.[1,2] Since that time, dental clinics and hospitals applied restricted infection control programs because of the risk of cross-infection.[3] World Health Organization (WHO), in turn, instructed people to use oral mouthwashes daily, to eliminate the risk of transmission of disease. This could be accomplished by reducing the amount of infectious virus.[4,5]

The American Dental Association recommended 30-sec gargling with 0.2% povidone-iodine (PVP-I) to reduce COVID-19 activity under affected levels. In addition, using PVP-I can reduce the viral load in the salivary secretion and could inhibit COVID-19 attachment to oral mucosa. PVP-I antiviral mechanism is through the free iodine liberated from PVP-I subvert the phospholipid virus envelope, and subsequently crumbling the viral nucleic acids.[6]

Furthermore, Scottish Dental Clinical Effectiveness Programs and International

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Federation of Endodontic recommend 1% hydrogen peroxide (H_2O_2) mouthwashes.[7,8] The gargling with 1% H_2O_2 has been anticipated to salivary viral load reduction in COVID-19. The oxidative ability of H_2O_2 could be the cause behind viral degradation.[8]

During the SARS-CoV-2 pandemic, 0.2% chlorhexidine (CHX) efficacy against COVID-19 infection was documented with controversy. Jain and his co-worker[6] reported that half- to one-minute gargling with CHX (0.12–0.2%) could be disabled high percentage of SARS-CoV-2. Unlike other study which disclosed that 30 sec gargling with 0.12% CHX attained only about 42.5% of COVID-19 virus.[9] However, CHX represented the golden mouthwashes for the treatment of the gingival disease and plaque control, as it has broad-spectrum antimicrobial activities.[10]

Cetylpyridinium chloride (CPC) is used in different types of mouthwashes because of their antimicrobial action. The lethal mechanism against COVID-19 includes its ability to interfere with the lipid components on the virus surface and interrupt their envelope integrity.[11,12]

In orthodontics, elastomeric power chains are used daily and regularly by orthodontists.[13,14] Many orthodontic cases could be treated by elastic chain, such as correction of the deviation of midline, correction of malocclusion, diastema closure, distalization of canine and de-rotation of teeth.[15–17] The flexible texture of power elastics, their ability to resist external forces and lower price make them essential parts of fixed appliances in orthodontic treatment. However, different factors could influence force decay of elastomeric chains, which include initial stretching, environmental experiments, pH, oral temperature changes, manufacture and design of chains.[15,16,18] Mouthwash is another influencing factor causing force decay, besides the bactericidal activity of the mouthwashes and buffering enhancement of the saliva.[19,20] These gargling were mainly used for fighting the dental caries and reducing the incidence of white spot lesions during orthodontic treatment.[16] However, some studies reported that power chain elastic efficacy decreases over time despite their ability to induce high forces, because of decrease in force degradation, which limits their use. The main causes of force degradation are mechanical, dimensional and morphological variances, the technique used in the manufacturing, oral wet environment and the secretions present in the oral cavity, pulling and temperature also greatly affect their mechanical properties.[21,22]

However, the effects of CHX and CPC on power chain force decay had been reported,[16,18,21,23] while the effects of daily prescribed mouthwashes recommended for fighting COVID-19 on force decay are unknown. The auspicious effects of H_2O_2, CPC and PVP-I against COVID-19 have been proved by numerous studies.[4,8,11] Their regular gargling throughout the recent COVID-19 pandemic in patients having fixed orthodontic appliances could be questionable regarding their side effects on the power chain elastics. Thus, this study aimed to compare the force decay of the stretched power chain elastics when exposed to these currently prescribed mouthwashes against COVID-19 pandemic (H_2O_2, PVP-I) with previously studied mouthwashes (CHX, CPC) according to prescribed concentration.

Materials and Methods

This trial study was conducted in the laboratories of the College of Dentistry, University of Mosul, October 2023 after the ethical reviewer board validated the approval of the study protocol (Approval No. 4S106 in 11\5\2022).

Power chains from two brands were used for this study (American Orthodontics (AO) (Sheboygan, USA) and Dentaurum (Ispringen, Germany). The sample size required for this study was calculated according to a parallel study[18] where alpha adjusted at 0.05, to get 85% study power.

A total of 600 pieces were used in this study, which represented the two brands (300 pieces each). Each piece of elastomeric chains was adapted to simulate canine retraction to the distal extracted space of the first premolar and has been stretched to 25 mm and fixed over stainless-steel pins. Each piece was composed of five loops with extra half loops bilaterally to facilitate handling and avoid sample distortion during cutting.

The samples were randomly grouped according to the study design into five groups to cover the five tested mouthwashes. The maximum tensile load failure testing (MTLT) was assessed at six sequenced time points [zero (as received), one hour, 24 hours, 1 week, 2 weeks and 4 weeks] using a modified adapter tensile testing machine (Gester Instruments Co., Fujian, China). The movable ends of this machine were modified with small pins to ensure sample hanging during a tensile test.

The tested mouthwashes used in this study were listed in Table 1 and were grouped randomly into five groups according to their type. The gargling concentrations were adjusted according to the WHO protocol, by diluting with distilled water for about 5 min before sample immersion. All the samples were incubated in distilled water at 37C° to resemble the oral environment.

All the tested pieces (600) were adapted in a parallel manner on the stainless-steel pins. The MTLT was measured by clamping the two ends of the elastomeric chain to the modified tensile machine pins switched at (5 mm/sec) speed. The resultant force was measured in Newton (N). The force induced was measured at the initial (zero time) in dry condition. All samples (except zero h) were incubated in distilled water and stored at 37 C°. Also, all samples were thermos-cycled 10 times per day by water bath, which was adjusted between 5 and 55C°, respectively. The samples were immersed for 30 sec in each bath (cold, hot) with a 30 sec exchanging time.

The power chain samples were taken out from incubated distilled water and immersed in their matching mouthwashes according to the WHO protocol for 60 sec, three times daily and this technique was repeated regularly till their specific prescribed time point. The mouthwash solutions were replaced before each immersion cycle. After immersion, the samples were transported to a new container filled with distilled water, marked for specific tested mouthwashes for 30 sec. Finally, the samples were re-stored into 100 ml of distilled water in the main incubator at 37C° specified for each group.

The force degradation was calculated at the five tested intervals comparable to the first group (zero h). SPSS software, version 26, was used to achieve the study statistics. The Shapiro–Wilk test was used for data exploration for normality. One-way analysis of variance (ANOVA) test was performed to analyse MTLT statistically among the tested elastic power chains at different searched time points and different mouthwashes. In addition, Tukey's HSD *post hoc* statistical test was performed for further significant difference results of ANOVA test. The P value was set to be at 0.05.

Results

Shapiro-Wilk test results displayed a normal distribution of the resultant data. The study's results of failure at the maximum tensile load testing (MTLT) are displayed in Table 2. MTLT mean and standard deviation of the two power chain elastics tested (AO, D) kept in dry condition were 21.57 (0.1358) and 20.41433 (0.1181) N, respectively, representing the received tensile strength of power chain elastics. ANOVA test results discover significant differences in MTLT of power chain elastics with different immersion intervals. In addition, in each tested group, MTLT decreased significantly as the immersion time increased. However, significant differences were observed among the tested mouthwashes at each time point. Tables 2 and 3 show the means and SD of the tested mouthwashes at different time intervals. Table 4 and Figures 1 and 2 show the percentage of force loss at each time point for all tested groups, which shows a

Table 1: Mouthwashes used in the current study with their abbreviations, manufactures details, chemical composition and their pH

Trade name	Abbreviation	Company/manufacture	Chemical composition	pH
Klorhex Chlorhexidine	CHX	Drogsan, Ankara, Turkey	2% chlorhexidine solution	6.5
Naturel hydrogen peroxide	H_2O_2	Naturel Medical Pharma, Istanbul, Turkey	3% hydrogen peroxide, 0.03% stabilizer, 96.97% solvent	7.3
Colgate Plax Cool mint	CPC	Colgate, London, UK	Aqua, glycerin, propylene glycol, poloxamer, aroma, cetylpyridinium chloride, potassium sorbate, sodium fluoride, sodium saccharin, menthol	7.1
Batticon	PVP-I	ADEKA, Istanbul, Turkey	10% povidone-iodine, solution, 1.5%, emulsifier, 0.5% stabilizer, 0.5% pH adjuster, 87.829% solvent	6.1
Distilled water	DW			7

Table 2: Descriptive statistics (mean and standard deviation in Newton) of force decay of American orthodontics power chain elastics at different intervals and different types of mouthwashes immersed

Disinfectant type	Zero	1 h	24 h	1 week	2 weeks	4 weeks	P*
DW	21.57^{F}	19.56^{E}	13.19267^{D}	12.31833^{C}	11.343^{B}	10.37533^{A}	0.000
	0.135892	0.137356	0.154405	0.20625	0.145664	0.100151	
CHX	21.57^{F}	19.46733^{E}	12.82^{D}	12.29867^{C}	11.268^{B}	10.46333^{A}	0.000
	0.135892	0.132165	0.240555	0.140441	0.096788	0.133752	
H_2O_2	21.57^{E}	18.90333^{D}	12.05333^{C}	11.523^{CB}	10.54523^{AB}	9.25^{A}	0.000
	0.135892	0.842312	0.118415	0.231517	0.371347	0.136382	
CPC	21.57^{F}	19.57733^{E}	12.82533^{D}	12.01233^{C}	11.4948^{B}	10.289^{A}	0.000
	0.135892	0.132165	0.11053	0.106697	0.13007	0.125573	
PVP-I	21.57^{F}	19.431^{E}	12.92333^{D}	12.18167^{C}	11.42233^{B}	10.36^{A}	0.000
	0.135892	0.143766	0.116714	0.107264	0.13413	0.106145	
P**		0.000	0.0000	0.0000	0.0000	0.0000	

*ANOVA statistical tests of force degradation at different time points intervals for each mouthwash. **ANOVA statistical tests of force degradation at same time points intervals for different mouthwashes. ***Different high letters upper case indicated significant differences as revealed by Tukey's *post hoc* test. $P<0.05$

Table 3: Descriptive statistics (mean and standard deviation in Newton) of force decay of Dentaurum power chain elastics at different intervals and different types of mouthwashes immersed

Disinfectant type	Zero	1h	24 h	1 week	2 weeks	4 weeks	*P**
DW	20.41433^{F}	18.45867^{E}	12.519^{D}	11.48233^{C}	11.01^{B}	9.768^{A}	0.000
	0.118199	0.159469	0.123323	0.159387	0.102307	0.160663	
CHX	20.41433^{F}	18.514^{E}	12.45433^{D}	11.50233^{C}	10.971^{B}	9.626^{A}	0.000
	0.118199	0.116356	0.135638	0.114823	0.134321	0.121855	
H_2O_2	20.41433^{E}	17.55333^{D}	11.36333^{C}	10.80333^{B}	10.25533^{B}	8.843333^{A}	0.000
	0.118199	0.194822	0.130724	0.229541	0.170069	0.10403	
CPC	20.41433^{E}	18.51467^{D}	12.82533^{C}	12.01233^{B}	11.4948^{B}	10.289^{A}	0.000
	0.118199	0.137223	0.11053	0.106697	0.13007	0.125573	
PVP-I	20.41433^{E}	18.53667^{D}	12.45667^{C}	11.36433^{B}	11.13233^{B}	9.906667^{A}	0.000
	0.118199	0.129185	0.194308	0.124141	0.175264	0.106249	
*P***		0.000	0.0000	0.0000	0.0000	0.0000	

*ANOVA statistical tests of force degradation at different time points intervals for each mouthwash. **ANOVA statistical tests of force degradation at same time points intervals for different mouthwashes. ***Different high letters upper case indicated significant differences as revealed by Tukey's *post hoc* test. $P<0.05$

Table 4: Descriptive statistics (mean and standard deviation) of percentage of force decay for both tested brands at different mouthwashes and intervals

Mouth wash	Brand	1 h%	24 h%	1 week%	2 weeks%	4 weeks%
H_2O_2	AO	13.36 (4.71)^{a}	45.11 (1.03)^{a}	47.58 (1.54)^{ab}	52.11 (1.85)^{a}	58.11 (0.51)^{a}
	D	15.00 (1.54)^{a}	45.33 (0.82)^{a}	48.07 (1.51)^{a}	50.74 (1.32)^{ab}	57.67 (0.50)^{a}
DW	AO	10.31 (0.09)^{b}	39.83 (1.05)^{b}	43.88 (1.18)^{c}	48.41 (0.63)^{bc}	52.88 (0.88)^{bc}
	D	10.56 (1.14)^{b}	39.66 (0.91)^{b}	44.74 (1.15)^{bc}	47.06 (0.97)^{c}	53.14 (1.30)^{bc}
CHX	AO	10.74 (1.24)^{b}	41.55 (1.77)^{b}	43.97 (1.20)^{c}	48.76 (0.56)^{bc}	52.48 (0.98)^{bc}
	D	10.30 (1.030)^{b}	39.99 (0.84)^{b}	44.6 (0.70)^{bc}	47.26 (0.66)^{c}	53.83 (0.93)^{b}
PVP-I	AO	10.92 (0.515)^{b}	41.08 (1.07)^{b}	44.51 (0.17)^{c}	48.04 (0.50)^{bc}	52.96 (0.95)^{bc}
	D	10.19 (0.98)^{b}	39.97 (1.48)^{b}	45.33 (0.94)^{abc}	46.45 (1.43)^{c}	52.46 (0.65)^{bc}
CPC	AO	10.23 (1.345)^{b}	41.52 (1.06)^{b}	45.30 (0.22)^{abc}	47.71 (1.14)^{bc}	53.28 (1.05)^{bc}
	D	10.30 (0.97)^{b}	41.18 (0.97)^{b}	45.21 (0.79)^{abc}	47.12 (0.67)^{c}	50.99 (1.52)^{c}
*P**		0.044	0.000	0.001	0.000	0.000

*ANOVA statistical tests of force degradation at same time points intervals for different mouthwashes. **Different high letters lower case indicated significant differences as revealed by Tukey's *post hoc* test. $P<0.05$

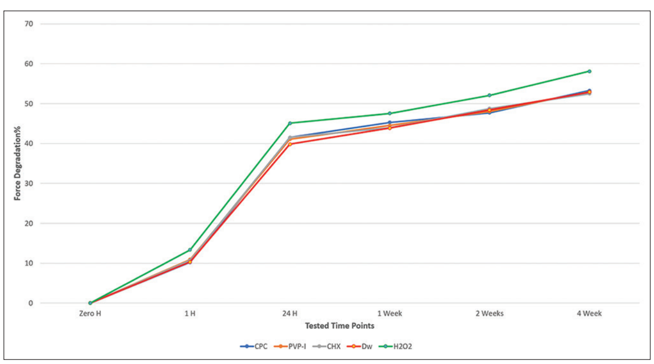

Figure 1: Comparison of the force decay of the American Orthodontic power chain elastics in the tested mouthwashes at the four-time points

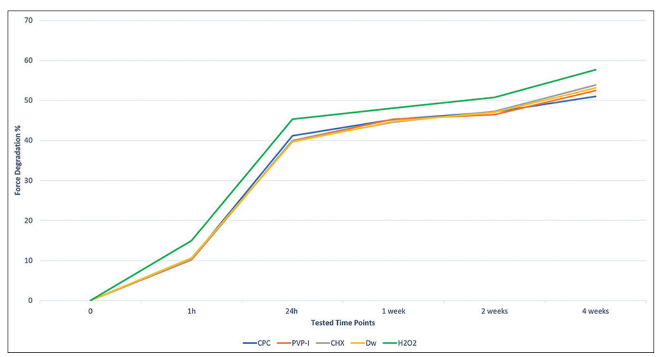

Figure 2: Comparison of the force decay of the Dentaurum power chain elastics in the tested mouthwashes at the four-time points

significant difference between the tested groups and at different time points. H_2O_2 group displays a maximum force loss throughout all the time intervals tested in this study for both tested companies, in contrast to other tested groups, which shows less degradation over time.

ANOVA test specified that power chain elastics that immersed to any mouthwashes tested through the current research revealed significantly less MTLT compared with the unused group. This significant difference was exhibited as the time of immersion increased, where $P < 0.05$.

Discussion

The recommendation of new mouthwashes during the COVID-19 pandemic that were not previously endorsed for orthodontic patients, make the inquiries regarding their effects on the force degradation of the power chain elastics. This study was designed to find out the effects of these mouthwashes on the force decay of the power chain elastics at sequenced time intervals. Also, this research was conducted in the laboratory to diminish the effects of possible confusing variables such as pH and temperature changes, besides stretching and mastication.

The measurements of force degradation were pointed at six intervals to display the force changes that occur among adjustment intervals. Five mouthwashes were tested in the current study. Three types of them were tested before. However, non-investigated two mouthwashes were the target of this study, which were not tested before (PVP-I and H_2O_2). The goal of using previously studied mouthwashes were for comparable purposes. All tested mouthwashes are recommended by the WHO during COVID-19 pandemic.[4,24]

To retract the canines and moving the teeth in the dental arch, elastomeric power chain is frequently used by clinicians because of their easy application, patient comfort, beside low cost and orthodontists' satisfaction.[25] The usual limitation of their preferable to the orthodontists is force degradation, as well as colour changes through time. This could be related to the natural of polyurethane polymer, which decayed in oral environment such as temperature variations, pH changes, oral rinses, teeth movements and salivary enzymes and masticatory forces.[22] During the COVID-19 pandemic, patients with orthodontic appliances carefully followed the gargling protocol adjusted by the WHO. According to the clinical observations, different effects were observed regarding the force degradation of the power chain elastics. In the current study, WHO mouthwashes protocol (CHX0.2%, PVP-I 1%, H_2O_2 and CPC), against COVID-19 was tested, to search for their effects on two brands of power chain elastics (AO, D).[24,26,27]

The force values reported at zero time or dry condition by this study were 21.57 (0.1358), 20.41433 (0.1181) N, for AO and D brands, respectively. These levels were above the clinically acceptable value required for the movement of single tooth (300 gm), as reported in the literatures.[28] After one hour, the power elastic chain of both brands loses about 10% of their initial force after immersed in different mouthwashes, except H_2O_2, which shows higher percentage loss rate (about 13%) for both tested brands. In addition, MTLT decreased significantly over tested time points, up to 51 to 54% residual force for two tested brands at the fourth week, except for H_2O_2 group, which shows a higher loss level reaches 57.6 to 58.1% for AO and D power chain elastic brands, respectively.

However, force degradation over time was observed and reported in previous studies. These could be physiologically acceptable.[22,28] The percentages of loss reported in the current study were coordinated with De Genova and his co-worker[29] outcomes and disagree with the other as they reported less force degradation ranges.[30,31]

However, the possible interpretation of force degradation after exposure to different mouthwashes and distilled water could include polymer distortion by stretching mechanism and fluid absorption. Polymer molecular chain slippage besides primary bond distortion yields to such permanent deformation, as stretching chain stresses their backbone molecule. In addition, it was reported that elastic polymer induces a plasticizer effect because of fluid absorption.[15]

As the fluid penetrated among the macromolecules of the power chain elastics polymer and initiate an internal force, which is able to separate polymer chains and swell polymer through secondary links break down.[32]

Variations in the initial force obtained were distinguished between two tested brands of power chains. The primary force delivered by AO was higher than D group, at all-time points. Despite equal tested piece size and distance between the loop's lumen, this could be related to differences in their chemical structure according to their manufacturer.

The current study focused on new mouthwashes recommended by WHO beside other types such as CHX and CPC for data validations and comparative evaluation between the groups.

Pithon *et al*.[22] noticed power chain force degradation when exposed to different concentrations of CHX, which is coordinated with this study outcome. In addition, the effects of mouthwashes containing CPC were evaluated by Issa *et al*.,[21] and their results were parallel to the result of the current study for all tested time points.

According to the results of this study, PVP-I mouthwash effect on the power chain force was such as the effects of CHX and CPC. PVP-I induced the least (nonsignificant) force loss compared with other testing solutions, and this could be attributed to the PVP-I content, which enhanced the linkages between polymer components and the polymeric chains, which, in turn, could retard polymer molecules' motion. This yield to reduce polymer chains sliding when subjected to tensile load.[33-37]

However, H_2O_2 exhibited the most significant force reduction from the first hour of immersion in comparison with the other mouthwashes reported in this study. This could be the yield of the oxidizing effects of H_2O_2 on the elastomeric polymer, as it can induce degradation of the polymer structure as the hydrogen ions in the H_2O_2 produced a significant morphological change leading to further in plasticizer-incorporating.[34,38]

In addition, the mouthwashes pH plays a major role in force degradation according to previously published literature studies. Pureprasert *et al*.[23] studied the effects of alkaline solutions on chain and found that it reduces the amount of loss at various elastic brands. In contrast, Lacerda dos Santos *et al*.[35] ignored pH effect on force loss at weak pH ranging between 5.0 and 7.5. However, the polyurethane derivatives were hydrolysed when the pH of immersed solution below 8.0,[13] as shown in Table 1

Although all tested mouthwashes used in this study potentially induced MTLT of the power chain elastics over time, this force loss was comparable to the zero group, which was exposed to distilled water. Accordingly, this amount of force degradation was accepted compared with clinical range during the total tested periods and therefore must be changed by new power elastic chain.[36,37]

Clinically, CPC could be recommended for use as an alternative gargling to overcome force degradations over time, and additional care should be taken during the use of H_2O_2 as a mouthwash if a patient has fixed orthodontic appliances. Further investigations are required to study the effects of different concentrations of newly prescribed mouthwashes by WHO on the durability of the power chain elastics. Also, this study neglects the effect of these mouthwashes on the colour of the power chain.

Conclusions

AO induces higher initial force rather than D brand; however, both brands are decade over time during exposure to CHX, CPC, H_2O_2 and PVP-I mouthwashes. PVP-I could be a good alternative to CHX and CPC regarding force degradation. H_2O_2 should be avoided in patients with fixed appliances because of their high degradation to power chain elastics.

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Conflicts of interest

There are no conflicts of interest.

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