Comparison of the Effect of Cetylpyridinium Chloride 0.05% and Povidone-Iodine 1%, Two Types of Mouthwash Effective Against COVID-19, on the Shear Bond Strength of Metal Orthodontic Brackets: a Laboratory Study

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Abstract

Introduction: Povidone-iodine 1% and cetylpyridinium chloride 0.05% mouthwashes have been used to remove microbial plaque and reduce gingivitis and the dysfunction of COVID-19. The present research was conducted to determine these two types of mouthwash effects on the shear bond strength of orthodontic brackets in laboratory conditions.

Method: In this experimental-laboratory research, healthy human premolar teeth were selected and preserved in 1% thymol. The samples were divided into three groups, including control and 0.05% cetylpyridinium chloride and 1% povidone-iodine mouthwashes. The shear bond strength values of the brackets were measured with a UTM device and with a blade speed of 1 mm/min After keeping each group in mouthwash and applying thermal cycles. The Adhesive Remnant Index (ARI) observed the amount of residual adhesive using a stereomicroscope at ten magnifications. The bond strength of brackets was investigated by one-way Analysis of Variance (ANOVA) in three groups, and pairwise comparisons were performed with Tukey's test. The chi-square test also analyzed the remaining adhesive degrees in the groups.

Results: Significant differences were observed in the shear bond strength of brackets in three groups (p=0.02). The bond strength of the brackets in the povidone-iodine mouthwash group was significantly higher than the control group (p=0.01). However, in other pairwise comparisons, no significant differences were observed between the groups. There were no significant differences in the amount of residual adhesive in the different groups.

Conclusion: Immersion in mouthwashes, effective against COVID-19, had no adverse effects on metal orthodontic brackets' shear bond strength values. Therefore, these mouthwashes can establish oral and dental hygiene and destroy COVID-19's function in orthodontic patients.

Keywords: cetylpyridinium chloride, povidone-iodine, shear bond strength, metal brackets.

INTRODUCTION

Standard orthodontic metal brackets are usually used in the structure of fixed orthodontic devices. (1).

One of the most critical problems of orthodontic treatment is the debonding between the bracket and the tooth, which disrupts the treatment process, increases its duration, and wastes significant time in the clinic to reattach the separated bracket (2). The strength of the bond in optimal bonding should be high enough to prevent the separation of the bracket in the process of orthodontic treatments. At the same time, the strength of the bond should not be such that it causes damage to the tooth in the debonding process. Even though debonding can occur at the contact surface of brackets and adhesive, inside the adhesive, or between the surface of enamel and the adhesive material, it is desirable that debonding takes place at the contact surface of brackets and adhesive to prevent tooth enamel damage (3). For this reason, as the bond strength increases, more pressure is applied to the enamel surface and the probability of enamel cracks during debonding increases. Accordingly, a suitable bonding is necessary to perform orthodontic treatments.

Shear bond strength is the main factor that should be considered in adhesive materials. Orthodontic brackets must be able to withstand the forces applied during orthodontic treatments. The forces of 8.7-9.5 MPa are enough to resist the gnawing forces.

Although good bonds of brackets have been obtained, various studies have reported their debonding rate during orthodontic treatments up to 6.17% (4).

It is essential to identify the right mouthwash that is suitable from the point of view of periodontal conditions and does not adversely affect bonding strength. Not paying enough attention to bonding strength can increase the probability of bracket debonding, lengthening treatment time, increasing caries and periodontal diseases, and finally, not achieving the desired result (5).

The outbreak of Coronavirus disease-2019, or COVID-19, in Wuhan, China, and then worldwide in the past few months, has drawn the attention of the world community and has resulted in numerous social, economic, psychological, and political consequences (6). The World Health Organization suggested that all countries control the person-to-person transmission of this disease and, as a result, its global spread to prevent the transmission of COVID-19. People's contact should be reduced with each other, especially the affected people and the employees of the care and treatment departments. (7)

COVID-19 is covered by a lipid layer that binds to the ACE2 receptor in the nasal cavity, pharynx, salivary glands, and respiratory epithelium. Close contact with patients, high viral load in saliva, and tools that produce aerosols make it necessary to use viral load reduction strategies. These strategies include preventive use by rinsing the mouth before the treatment process to reduce the viral load in the pharynx and air and reduce the risk of transmission of SARS-Cov-2 infection in the dental environment. According to the Centers for Disease Control (CDC) guidelines, cetylpyridinium chloride mouthwash is recommended for this purpose according to its lysosomotropic mechanism and its ability to destroy viral capsids. The covid-19 virus can quickly enter people's mouths and respiratory tract through airborne droplets and enter the lungs by accumulating in the pharynx and nasopharynx, causing severe pneumonia. The significant lethality of this virus and the deterioration of the condition of infected people clearly show the necessity of using masks and social distancing. Since people undergoing orthodontic treatment always have the feeling of being in a foreign body and fullness in the mouth, it is more difficult for them to use a mask due to the half-open lips and drying of the vermilion and inner mucus of the lips (8).

Nevertheless, using a mask is more difficult for people undergoing orthodontic treatment. Because they always feel the fullness of the mouth and the presence of a foreign body, their lips are usually half-open, and vermilion and the inner mucosa of the lips are dry (8). On the other hand, not using a mask or misusing it can lead to the accumulation of viruses and contamination in people's mouths. Due to the antimicrobial and antiviral properties of mouthwashes, their continuous use can also reduce the possibility of contracting the Covid-19 virus (9).

The positive effects of cetylpyridinium chloride and povidone-iodine mouthwashes have been proven to prevent the infection of the covid-19 virus (10). Povidone-iodine mouthwash quickly penetrates the virus with the slow release of a water-soluble iodine complex and the oxidative effect and destruction of the fat shell with minimal toxicity, disrupting the function of viral proteins and oxidizing nucleic acid structures and causing the death of the virus. In addition, cetyl pyridinium and povidone-iodine mouthwashes effectively remove bacterial plaque and reduce gum inflammation (11).

Research has also been done in this field; Bano-Polo et al. (2022) investigated the potential of cetylpyridinium chloride as an inhibitor of COVID-19. This research concluded that including CPC in mouthwashes can be a preventive strategy to prevent the spread of SARS-CoV-2 (12). Sajjadi et al. (2021) determined the effects of mouthwash application on the shear bond strength of orthodontic brackets. According to the research results, these differences were not statistically significant despite the decrease in the shear bond strength values of the brackets in the mouthwash group compared to the control group (13). Choudhury et al. (2021) investigated the effects of using 1% povidone-iodine mouthwash in patients with Covid-19. According to research results, patients who used 1% povidone-iodine mouthwash experienced significant reductions in mortality, hospital complications, and the financial burden associated with the disease. Therefore, the administration of 1% povidone-iodine mouthwash as mouthwash and gargling has effectively reduced mortality and complications caused by covid-19(14). Farzan and Firoozi (2020) investigated the common and effective mouthwash for rinsing purposes in dental treatments to eliminate COVID-19. According to the research results, povidone-iodine and chlorhexidine mouthwash were effective against COVID-19, and povidone-iodine mouthwash was effective against other viruses, including SARS-CoV, MERS-CoV, influenza virus, and rotavirus. At the same time, the antiviral effects of chlorhexidine against COVID-19 have been limited. Therefore, povidone-iodine mouthwash has been the only approved agent for rinsing in dental treatments to clear COVID-19 (15).

Gupta et al. (2020) investigated the shear bond strength of orthodontic brackets cemented to natural teeth after immersion in different drinks. This research concluded that consuming soft drinks after cementing orthodontic brackets had no significant effects on debonding brackets (16). Hossein et al. (2019) determined the impact of pre-bonding with chlorhexidine and ethanol on the shear bond strength values of the resin-dentin composite. The research results showed that the preparation of the dentin surface with 2% chlorhexidine and 100% ethanol mouthwashes effectively reduced the shear bond strength of composite to dentin for up to 6 months of maintenance (3). Pinheiro et al. (2019) determined the effects of surface preparation methods and mouthwash application on the bond strength of composite restorations. Their findings showed that the samples placed in distilled water had more complex surfaces than the other experimental groups, but no significant differences were observed among the other groups. In addition, the immersion environment and mechanical surface preparation did not significantly affect bond strength values (17).

In general, mouthwash is an inseparable part of orthodontic treatments. The use of orthodontic wire and appliances causes problems in oral and dental hygiene and facilitates tooth decay. Therefore, to deal with these problems, orthodontists encourage patients to use different methods to maintain oral and dental hygiene, of which mouthwash is a part of these methods. Several mouthwashes, including cetylpyridinium chloride and povidone-iodine types of mouthwash, have been used in the past few years to combat COVID-19. Few studies have investigated the relationship between mouthwashes and the bonding of orthodontic brackets. In this regard, the current research was conducted to determine the effects of cetylpyridinium chloride and povidone-iodine mouthwashes effective on COVID-19 on the shear bond strength of orthodontic metal brackets.

MATERIALS AND METHOD

This research was conducted using the experimental in-vitro method after review and approval by the Supreme Research Council of the University and obtaining the code of ethics under the number IR.ABZUMS.REC.1401.074 in the Orthodontics Department of the Faculty of Dentistry of Alborz University of Medical Sciences and Dental Biomaterials Laboratory.

The studied population included 45 healthy human premolars extracted for orthodontic reasons. The number of samples was determined based on the results of Singh et al. (2018) (18) and in a simple non-random way (available sample). The samples were divided into three groups of 15:

Group 1- Distilled water as the control group

Group 2- Cetylpyridinium chloride mouthwash 0.05%

Group 3- 1% povidone-iodine mouthwash

Figure 1 shows the studied groups.

The inclusion criteria of the teeth in the research tests were the absence of caries and hypoplastic and dental cracks. Teeth with caries, cracks, and hypoplastic were excluded from the study to eliminate confounding factors. The teeth were kept in 1% thymol at room temperature (18) for four weeks.

A universal test machine and stereomicroscope were used to collect data in the research.

The buccal surface of the entire tooth was etched using the total-etch technique and 37% phosphoric acid (Denfil, South Korea) for 30s, washed and dried for 20s. The buccal surface of each tooth was coated with bonding, and curing was done according to the manufacturer's instructions. Stainless steel orthodontic brackets (American Orthodontics Brackets, 0.022 MBT Compatible) are attached to the surface of the teeth by Transbond XT composite (Light-cure adhesive, 3M Unitek, CA, USA). The curing is performed by the LED light cure device (Woodpecker, China) with a power of 21000 w/m and in ortho mode. According to the manufacturer's instructions, the composite was performed for 10s in the mesial and 10s in the distal of each bracket (18).

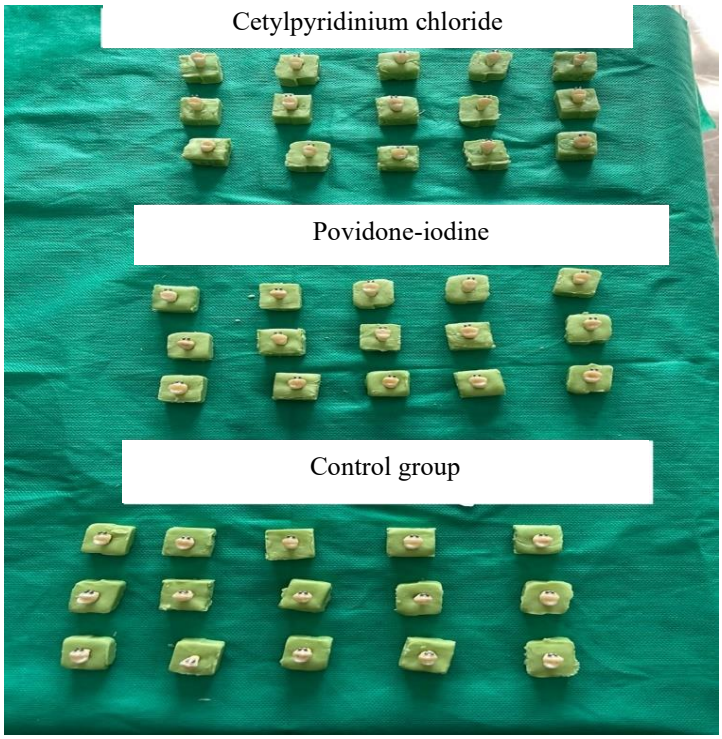

Figure 1- Mounting the samples inside the acrylic blocks

After connecting the brackets to the teeth, (a thermocycler was performed between 55-55°C for 3000 cycles. The teeth were placed inside water for 20s and 15s outside at 55°C, 20s inside water, and 15s outside at 5°C. Then, each group was placed in its mouthwash for 12 hours (46). Shear bond strength values of orthodontic metal brackets were measured by Universal Testing Machine (UTM, Zwick Roell Z050, Ulm, Germany) with a blade speed of 1 mm/min and by blades with an end thickness of 0.5 mm under parallel shear forces. The shear force in newtons and the strength of the bond were determined in megapascals for each sample.

After removing the brackets, the amount of adhesive residue was observed by the ARI index (adhesive remnant index) on the teeth using a stereomicroscope (Nikon ZMZ 800, Japan) with a magnification of 10. The teeth were divided into one of the following four groups (18).

Grade zero: no adhesive left on the tooth.

Grade one: less than 50% adhesive remains on the tooth.

Grade two: more than 50% remains on the tooth.

Grade three: all the adhesive remains on the tooth.

Finally, the data were analyzed using Statistical Package for Social Sciences software: SPSS version 0.25. Hence, the mean and standard deviation of the shear bond strength of the brackets and the frequency and percentage of different adhesiveness grades in the groups were calculated. Due to the variable quantitative nature of shear bond strength values, its comparisons in three groups were made with a one-sided analysis of variance (ANOVA), and pairwise comparisons of groups were also made with Tukey's pairwise comparisons test. The comparisons of the remaining adhesive degrees in the studied groups were also made with the chi-square test. The first type of error in the present research was determined at about 0.05 (α=0.05).

FINDINGS

1 Central dispersion indices of shear bond strength of brackets in different groups:

Figure 1 shows the mean and standard deviation of the shear bond strength of brackets in different groups. The highest values of the shear bond strength of the brackets were seen in the povidone-iodine group, followed by the cetylpyridinium chloride mouthwash group, and the lowest values of the shear bond strength of the brackets were also recorded in the control group.

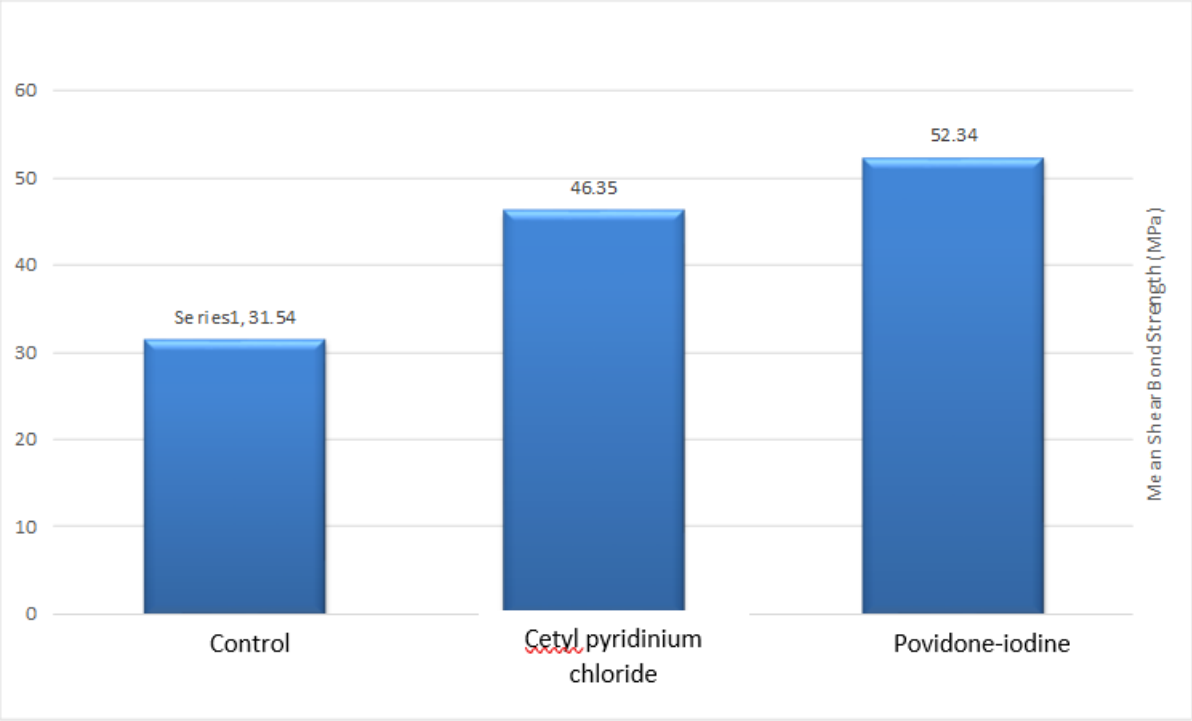

Diagram 1- mean and standard deviation of shear bond strength of brackets in different groups

The comparison of the mouthwashes effects on the values of the shear bond strength of brackets in pairwise groups:

Table 2 compares the shear bond strength values of brackets in pairwise groups using a one-way analysis of variance (ANOVA) test. (p=0.02).

On the other hand, Tukey's multiple comparisons tests showed significant differences between the values of the shear bond strength of brackets in the control and povidone-iodine mouthwash groups (the mean difference between the two groups was

20.79 MPa, p=0.01). However, there were no significant differences between the control groups and the 0.05% cetylpyridinium chloride mouthwash (the mean difference between the two groups is 14.81 MPa, p=0.14) as the 0.05% cetyl pyridinium chloride and povidone-iodine mouthwash groups. (The mean difference between the two groups is equal to 5.98 MPa, p=0.86) (Table 2-3).

Table 2- Comparison of the values of shear bond strength of brackets in pairwise groups

Group 1	**Group 2**	**mean difference**	**Standard error**	**P value**
control	Cetylpyridinium chloride	14.81	6.84	0.14
control	Povidone-iodine	20.79	6.03	0.01
Cetylpyridinium chloride mouthwash	Povidone-iodine	5.98	8.36	0.86

Determining the amount of residual adhesive on teeth (ARI) after removal of orthodontic brackets in different groups

Table 3 shows the residual adhesive grades after removing orthodontic brackets in different groups. The chi-square test showed no significant differences in residual adhesive degrees after removing orthodontic brackets in other groups (p=0.81). According to the results of the research, in the control group, 1 sample (6.7%) has a residual adhesive grade equal to zero, five samples (33.3%) have grade 1, 5 samples (33.3%) have grade 2, and 4 samples (26.7%) had the residual adhesive grade of 3. In the cetylpyridinium chloride mouthwash group, two samples (13.3%) had a residual adhesive grade of zero, four samples (26.7%) had a residual adhesive grade of 1, 4 samples (26.7%) had a residual adhesive grade of 2 and 5 samples (33.3%) had the residual adhesive grade of 3. In the povidone-iodine group, 1 sample (6.7%) had a residual adhesive grade of zero, three samples (0.20%) had a residual adhesive grade of 1, 3 samples (0.20%) had a residual adhesive grade of 2, and 8 samples (53.3%) had the residual adhesive grade of 3.

Table 3- Amount of residual adhesive after removal of orthodontic brackets in different groups

Adhesive grades group	Grade zero	Grade one	Grade two	Grade tree	Total
control	1 (%6.7)	5 (%33.3)	5 (%33.3)	4 (%26.7)	15 (%100.0)
Cetylpyridinium chloride mouthwash	2 (%13.3)	4 (%26.7)	4 (%26.7)	5 (%33.3)	15 (%100.0)
Povidone iodine	1 (%6.7)	3 (%20.0)	3 (%20.0)	8 (%53.3)	15 (%100.0)

DISCUSSION

The present study was conducted to determine the effects of 0.05% cetylpyridinium chloride and 1% povidone-iodine mouthwashes effective on COVID-19 on the shear bond strength of orthodontic metal brackets.

According to the results of this research, there were significant differences in the shear bond strength values of brackets in the control and 1% povidone-iodine mouthwash groups, and the strength values in the mouthwash group were higher than the control group.

Povidone-iodine is a disinfectant compound that can remove COVID-19 (19). This combination is used in clinical conditions to disinfect the skin before and after surgery and prevent opportunistic pathogens. Povidone-iodine is more effective than chlorhexidine for hand disinfection. Povidone-iodine also contains hypoiodous acid and has oxidized living structures such as amino acids, acid nuclides, and membrane compounds of pathogens (69). A povidone-iodine mouthwash of 1% can reduce the viral load, such as MERS-CoV, in the mouth and throat environment, and because it is alcohol-free, it does not hurt the strength of the shear bond (70). Similarly, in the study of Singh et al. (2018), the values of the shear bond strength of orthodontic brackets after the application of different mouthwashes were investigated, and the highest values of the shear bond strength were observed in the artificial saliva group and then in the herbal mouthwash and chlorhexidine groups. 18). Alcohol-containing mouthwashes such as Listerine reduce dental plaque and improve oral health. However, the alcohol content decreases the strength of the shear bond of brackets and causes a burning sensation in the mouth of patients (19). In the present research, brackets' lowest shear bond strength values were observed in the Listerine alcohol-based mouthwash group.

In the present study, there were no significant differences between the control and cetylpyridinium chloride mouthwash groups, as well as mouthwash groups. Therefore, immersion in mouthwashes effective against COVID-19 did not significantly affect the changes in the shear bond strength of brackets. On the other hand, the values of the shear bond strength of brackets in all three investigated groups were higher than the specified values, indicating the ability to use mouthwashes to maintain oral and dental hygiene without adverse effects in the values of the shear bond strength of the brackets.

In most cases in research backgrounds, the use of mouthwashes has caused a decrease in the shear bond strength of brackets to teeth. For example, Jamilian et al. (2010) investigated the effects of Ortho Kin and Oral B mouthwashes on the shear bond strength of orthodontic brackets. They reported that using Ortho Kin and Oral B mouthwashes after bonding the brackets decreased their shear bond strength. However, the bond strength values obtained were still higher than the minimum acceptable shear bond strength values in clinical conditions (50). These findings are different from the results of the present study. Because the mouthwashes examined in the research had increased the values of the shear bond strength of the brackets compared to the control group. This increase could be due to the type of composite used and the different nature of the mouthwashes in the two studies.

In the study by Kupka et al. (2018), cetylpyridinium chloride was used in concentrations of 0.5 to 2% in the manufacture of glass ionomer cement, and according to the research results, the hardness and tensile strength of the group using this mouthwash increased compared to the control samples (20). Because cetyl pyridinium chloride is a quaternary ammonium salt, it can interact with poly (acrylic acid).

The location of debonding can occur in three areas: The contact point of enamel-adhesive, bracket-adhesive (adhesive failure), or a combination of the two. The best case is that the outermost layer of enamel should remain intact as much as possible. For this reason, debonding at the bracket-adhesive contact point is preferred by most orthodontists due to the lower probability of enamel cracking and damage because the adhesive left on the tooth can be removed from the tooth with conservative methods without damaging the enamel.

In this research, the teeth were divided into four groups after evaluation with the remaining adhesive index:

Grade zero (no adhesive left on the tooth). ARI index, which indicates a weak connection in the enamel-adhesive area. Grade one (less than 50% adhesive left on the tooth), Second grade (more than 50% of the adhesive remains on the tooth), and third grade (all the adhesive remains on the tooth), which indicates a weak connection in the adhesive-bracket area (22).

In the present study, no significant differences were seen in the amount of residual adhesive after removing orthodontic brackets. However, in the povidone-iodine mouthwash group, more than 50% of the adhesive remained on the enamel of most teeth surfaces (about 73%). Povidone-iodine is the best mouthwash in bond strength and ARI index.

The tooth's surface must be thoroughly cleaned and dried before the bonding process to establish a proper bonding. All the brackets were attached to the tooth surfaces within 5s. A thin and adhesive layer was created between the tooth and bracket. This matter is crucial because it has been found that the strength of the shear bond decreases as the adhesive thickness increase. The type of applied adhesive also influences the shear bond strength of brackets. Light cure adhesives such as Transbond XT, used in this research, may have inappropriate bonding forces in thicknesses of 0.2 mm. However, other adhesives, such as Concise, are not affected by thickness (23).

The type of shearing forces is also significant in estimating brackets' shear bond strength. Inside the mouth, brackets are continuously subjected to torsional, tensile, shearing, or a combination of these. Shear forces are usually suitable for checking the strength of the bond between the tooth surface and the base of the brackets (24). These shearing forces in the Instron device have reproducibility, and it is possible to compare them. Of course, there are still discussions about the maximum bond forces of brackets.

Different values for bond strength of orthodontic brackets have been reported in previous research. Germec et al. (2009) declared the range of acceptable bond strength for bonding brackets as 5-8 MPa (25). Considering these criteria, the values of shear bond strength obtained in the present research were acceptable in all groups.

In this research, the shear bond strength test was used as a standard method with optimal control of the tools and with an acceptable level of reproducibility. This method is very similar to the clinical conditions in the human mouth, and the chewing forces exert more force on the brackets with a higher probability. It has been reported that laboratory methods such as compression, shear, torsion, or bending tests have different results, and their findings differ in many ways (26). The experiment design technique is also effective in the generalizability and estimation of the accuracy of the results, and the applied forces produce torques that depend on the distance of the force axis from the resistance center. On the other hand, the minimum number of samples required for the shear bond strength test is 10. In this research, this issue was observed.

The speed of the blade tip during the shear test in the present research was considered equal to 0.1 mm/min. Most studies about the research topic have used the range of blade tip speed equal to 0.10-10 mm/min for the shear bond strength test. Of course, these values are not consistent with the clinical conditions inside the mouth because the chewing speed range is 81-100 mm per second or 4860-6000 mm per minute, and its frequency is reported in the range of 1.03-1.2 Hz (26).

The conventional bracket bonding system in orthodontic treatments includes Transbond XT bonding, which includes acid gel, primer, and adhesive. This system is used to bond orthodontic brackets to enamel surfaces or existing restorations on teeth as a

conventional orthodontic choice. The Transbond XT system is also the gold standard choice in research related to the shear bond strength of orthodontic brackets to compare the application results of new products (27). In this regard, this system was also used in the present research to compare the results.

According to the current research protocol, the samples were subjected to thermal cycles, and then the shear bond strength of the brackets to the tooth enamel surfaces was measured. The results of studies in which thermal cycles were not applied to the samples are believed to be biased.

At the same time as the COVID-19 pandemic and despite the unknown aspects of this virus, centers and organizations such as the World Health Organization and health organizations in the United States have prepared and presented guidelines to control and prevent the transmission of diseases. The underlying principle and basis of all of them are that all patients are potentially infectious. Using devices and equipment in dental clinics and related treatment centers requires ensuring their safety. In addition, since only some of the equipment used in hospitals and medical centers are disposable, cleaning them for future use is inevitable. Deciding on how to perform the cleaning process and its quality depends on how to use the desired device.

Laboratory research, such as the current research, has a fundamental limitation: the multifactorial environment inside the mouth cannot be simulated with current research and laboratory methods because there are many factors, such as the role of saliva, behaviors related to the patient, or other factors. Therefore, using laboratory methods is only a preliminary step in determining the effectiveness of anti-caries materials when used in orthodontic treatments.

Conclusion

The results of the current research on the effects of mouthwashes effective against COVID-19-cetylpyridinium chloride 0.05% and povidone-iodine 1% on the shear bond strength of orthodontic brackets in laboratory conditions showed that:

There was a significant difference in the shear bond strength of brackets among the three groups ($p=0.02$). The bond strength of the brackets in the povidone-iodine mouthwash group was significantly higher than the control group ($p=0.01$). However, no significant differences were observed between the groups in other pairwise comparisons. There was no significant difference in the amount of residual ARI adhesive in the different groups. However, in the povidone-iodine mouthwash group, more than 50% adhesive remained on the surface enamel of most teeth (about 73%), and overall, it is the best mouthwash to use both in terms of bond strength and ARI index. Therefore, immersion in mouthwashes effective against COVID-19 has no adverse effects on the values of the shear bond strength of metal orthodontic brackets. Under the conditions of this research, these mouthwashes can be used to establish oral and dental hygiene and destroy the function of COVID-19 in patients. Finally, it should be mentioned that for further investigations, future researchers can deal with the effects of immersion in different mouthwashes on the mechanical properties of orthodontic appliances.

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