

Effect of Mouthwashes on the Surface Roughness of Stainless Steel Orthodontic Brackets

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Background: This study aimed to evaluate the effect of three oral mouthwashes on the surface roughness of stainless steel orthodontic brackets from two commercial brands, ORMCO and 3M Unitek.

Methods: A total of sixty upper bicuspid stainless steel brackets were used, divided equally between the two brands: 30 ORMCO brackets and 30 3M Unitek brackets. Each brand group was further subdivided into three subgroups of ten brackets, with each subgroup immersed in one of three oral rinses: water and salt solution, LISTERINE™ sodium fluoride mouthwash and OREX™ sodium fluoride mouthwash. Surface roughness was measured using an optical profilometer after 90 minutes of immersion and again after seven days, to assess the potential influence of exposure duration on surface roughness.

Results: One-way ANOVA revealed no statistically significant differences in surface roughness among most groups ($p \geq 0.05$). The highest surface roughness was observed in the ORMCO brackets immersed in OREX fluoridated mouthwash for seven days (mean = $0.9169 \mu\text{m}$). The lowest was in the 3M Unitek group immersed in the water and salt solution for 90 minutes (mean = $0.9130 \mu\text{m}$). Although the roughness values showed a statistically significant difference, the magnitude of the difference was minimal ($0.0039 \mu\text{m}$) and considered clinically insignificant.

Conclusion: This study found that sodium fluoride mouthwashes resulted in slightly higher surface roughness of stainless steel orthodontic brackets compared to water and salt rinse. However, the differences are not clinically relevant and will not impact plaque accumulation or bracket function.

Keywords: stainless-steel, orthodontic brackets, sodium fluoride, mouthwash, oral rinse, water and salt

Introduction

Correcting malocclusion through orthodontic treatments, particularly arch-guided tooth movement, is demonstrably effective.^{1,2} However, concerns arise regarding the impact of bracket surface roughness on plaque accumulation and oral hygiene maintenance effectiveness during orthodontic treatment.^{3,4} Rougher surfaces promote plaque retention, while meticulous cleaning becomes more challenging with brackets being placed on tooth surfaces.^{3,4} This can negatively affect periodontal health and lead to demineralization around the brackets, potentially resulting in white spot lesions and caries.^{3,4} Mouthwashes, usually used as antiseptic breath fresheners, are often employed as adjuncts to brushing and flossing to supplement the primary method of cleaning, which offer additional plaque control and anti-inflammatory benefits, making them especially valuable during orthodontic treatment.⁵⁻⁷ During the active phase of orthodontic treatment, mouthwashes are recommended since they are clinically effective in reducing plaque accumulation and because of their anti-inflammatory effect.^{4,8} However, certain mouthwashes containing alcohol or acids can minimally cause a decrease in the corrosion resistance, metal ion release, and discoloration of stainless steel brackets in rare cases, compromising their integrity and potentially promoting further microbial adhesion and secondary caries.⁹⁻¹⁵ Furthermore, such effects may negatively impact periodontal health through increased plaque accumulation and gingival irritation.¹⁶⁻¹⁸ Despite acknowledging the potential drawbacks of certain mouthwashes, existing research lacks sufficient laboratory data on the correlation between the surface

roughness of orthodontic brackets and immersion in various mouthwash solutions. This research addresses this gap by investigating the relationship between orthodontic bracket surface roughness and a diverse group of commonly used mouthwashes. This analysis will encompass water and salt rinses alongside commercially available mouthwashes, allowing for a comprehensive understanding of their individual and comparative effects on surface roughening. Notably, this study will employ optic surface profilometry, a technique not frequently utilized in previous research within this field. This study contributes to the existing body of knowledge by examining the previously underexplored influence of various mouthwashes on orthodontic bracket surface roughness, shielding light on the importance of analyzing the surface roughness since the roughened surface can lead to an increase in the adhesion of microorganisms, which increases the potentiality of secondary caries. Moreover, it could also affect periodontal health and lead to plaque accumulation and gingival irritation. The findings will help clinicians recommend optimal oral hygiene practices for their patients undergoing orthodontic treatment, ultimately promoting improved oral health outcomes. Therefore, the aim of this study was to evaluate the effect of different mouthwashes on the surface roughness of stainless steel orthodontic brackets. The null hypothesis tested was that immersion in various mouthwashes would not produce significant differences in surface roughness compared to baseline values.

Materials and Methods

Study Design

This laboratory-based study follows a quantitative design. A total of 60 upper-right bicuspid stainless steel orthodontic brackets were used (30 ORMCO and 30 3M Unitek). Each brand was divided into three subgroups ($n = 10$), and each subgroup was immersed in one of three solutions: LISTERINE™, OREX™, or a water and salt rinse (Figure 1). The water and salt rinse were prepared by dissolving 5 g of sodium chloride in 250 mL of distilled deionized water using a precise digital analytic electronic weighing scale. All samples were stored in an incubator at 37 °C (Table 1). The basement (initial) value of the bracket samples before the immersion procedure was decided as the control group. The effect of the three solutions on the surface of the slot floor of orthodontic brackets was evaluated by subjecting them to surface roughness tests before the immersing procedure (control group). It was further evaluated after 90 minutes stored in an incubator at 37 °C, representing an accelerated in-vitro simulation of daily mouthwash use, as previously described.¹⁰ Another measurement was done after seven days, where samples were stored in an incubator at 37 °C to investigate if increasing the sample immersion time duration would increase the brackets' surface roughness.⁸ Furthermore, the bracket was held at the untested bracket corners with the help of a tweezer and transported to the optic profilometer device to test the surface roughness of the bracket slot.

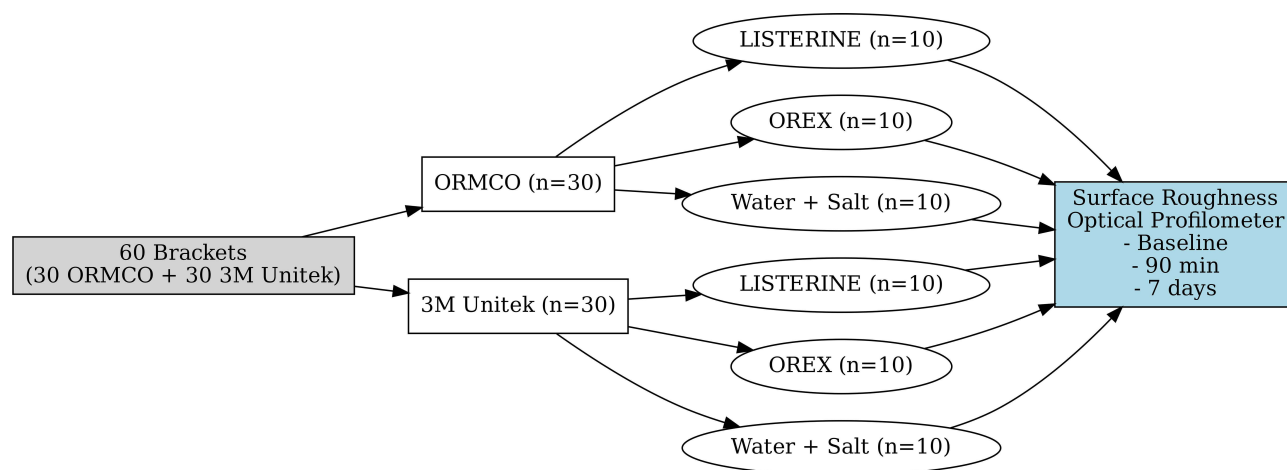


Figure 1 Study design schematic illustrating the experimental design.

Table 1 Materials Used in the Laboratory Study

Material	Composition	Manufacturer	LOT No.
3M™ Victory Series™ Low Profile Bracket	Stainless Steel	3M Unitek Orthodontic Products CA 91016 USA	LX2MH
ORMCO™ Mini Diamond Twin orthodontic bracket	Stainless Steel	ORMCO CORP. 1332 S. Lone Hill Avenue, Glendora, CA 91740–5339	071723188
LISTERINE™ Sodium Fluoride Mouthwash	Aqua, Propylene Glyco., Sorbto, Sodium Laury Sultate, Poloxamer 407, Sodium Sacchain, Aroma Eucalyptol, Benzoic acid, Sodium Benzoate, Methyl Salicylate, Thymol, Sodium Fluoride, Menthol, Sucralose, Camellia Sinensis Leaf Extract, Caffeine, CI 47005, CI 42053. Contains Sodium Fluoride (220 ppm F-).	JOHNSON & JOHNSON GmbH, D-41470 Neuss DE LISTERINE Made in Italy	691760
OREX™ Sodium Fluoride Mouthwash	Aqua, Sorbitol, PEG-40 Hydrogenated Castor Oil, Glycerin, Poloxamer 407, Aroma, Sodium Methylparaben, Sodium Propylparaben, Citric Acid, Cetyloyridinium Chloride, Sodium Benzoate, Sodium Fluoride, Sodium Saccharin, CI 18965, CI 42090. CONTAINS: Cetylpyridinium Chloride 0.05% w/w, Sodium Fluoride (225ppm F-).	Manufactured by Nahdi Medical Co. by FUSHIMA, S.L. Pol. Ind. Guarnizo I 39611 Guarnizo - Cantabria (Spain)	230241
Water and Salt Oral Rinse	5 grams of salt (NACL) was dissolved in 250 ML distilled deionized water		

Abbreviation: PEG=Polyethylene Glycol, PPM F= Parts Per Million Fluoride, NACL=Sodium chloride.

Sample Preparation

The samples were categorized into six groups, each using ten samples to be measured by the optic profilometer device (Figure 2). The preparation of samples for the optic profilometer device is shown in Figure 2A, while the preparation of

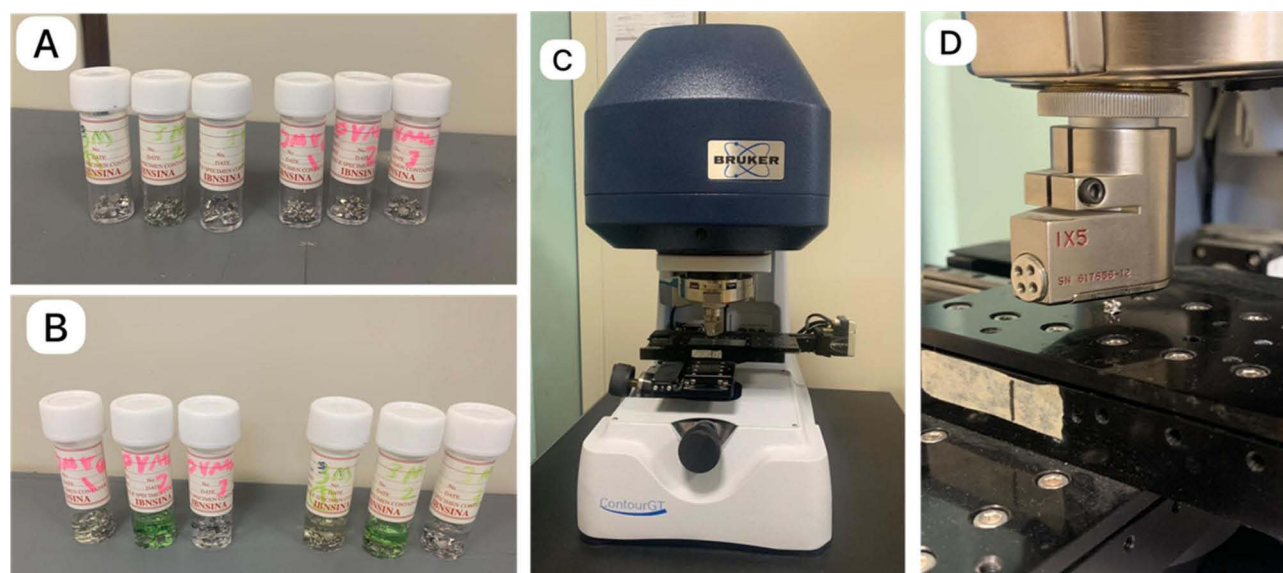


Figure 2 Sample preparation for the optic profilometer device. (A) Sample preparation for the orthodontic brackets into six groups before the immersion in mouthwashes. (B) Sample preparation for the orthodontic brackets into six groups after the immersion in mouthwashes. (C) Optic Profilometer device (BRUKER). (D) The position of the sample on the optic profilometer device for the surface roughness test.

orthodontic brackets before immersion in mouthwashes is presented in [Figure 2B](#). The preparation after immersion is shown in [Figure 2C](#), and the optic profilometer device setup for surface roughness testing is illustrated in [Figure 2D](#).

Group one: 3M stainless steel brackets immersed in a fluoridated mouthwash (LISTERINE) Group two: ORMCO stainless steel brackets immersed in a fluoridated mouthwash (LISTERINE) Group three: 3M stainless steel brackets immersed in fluoridated mouthwash (OREX) Group four: ORMCO stainless steel brackets immersed in Fluoridated mouthwash (OREX) Group five: 3M stainless steel brackets immersed in mouthwash (Water and Salt rinse) Group six: ORMCO stainless steel brackets immersed in mouthwash (Water and Salt rinse).

Evaluation of Surface Roughness Using Optical Profilometry

A three-dimensional optical surface profilometer (ContourGT, Bruker, Campbell, CA, USA) was used to examine the surface characteristics of the orthodontic brackets. The surface roughness was evaluated using non-contact scanning white light interferometry (WLI) with 0.05 m accuracy, and the scanning area was situated at the center of the surface. The device calculated the SA value (arithmetical mean height), the average roughness over a region. The application program Vision64 (v5.30, Bruker, Campbell, CA, USA) was used to ensure that the measurement was precise and accurate for the surface roughness characteristics. The initial (before immersion in mouthwashes) and final readings will be obtained in the same targeted area of the bracket samples (after immersion in mouthwashes).^{19,20}

Statistical Analysis

To analyze the data, SPSS Version 21 was used (SPSS, Chicago, IL, USA). The reported values for continuous variables were the mean and standard deviation (SD), and to compare the means, a one-way ANOVA was used. A p-value of ≤ 0.05 is considered statistically significant.

Results

Surface roughness was assessed using non-contact scanning white light interferometry (WLI) to determine the arithmetical mean height of a line (Sa), which represents the average roughness over a measured area.^{19,20} The 3M Unitek Orthodontic brackets were divided into three subgroups ([Table 2](#)): LISTERINE, OREX, and water and salt oral rinse. Surface roughness measurements across all experimental groups showed insignificant increases in the 90-minute and seven-day intervals, except for the OREX mouthwash group after seven days ($P = 0.0454$). Specifically, the mean (Sa) of the OREX group after 90 minutes was 0.9146μm, slightly higher than those of the LISTERINE (0.9138μm) and water

Table 2 Surface Roughness Measurements for the 3M Unitek Orthodontics Bracket

3M Unitek Orthodontics Bracket				
Group Name	Treatment	Mean	Std. Dev.	P value
LISTERINE	Control Group	0.9124	± 0.004	
	Experimental 90 Minutes	0.9138	± 0.005	0.4981
	Experimental 7 Days	0.9149	± 0.004	0.1792
OREX	Control Group	0.9124	± 0.004	
	Experimental 90 Minutes	0.9146	± 0.003	0.1811
	Experimental 7 Days	0.9158	± 0.003	0.0454*
Water and Salt	Control Group	0.9124	± 0.004	
	Experimental 90 Minutes	0.9130	± 0.002	0.6764
	Experimental 7 Days	0.9136	± 0.002	0.4073

Notes: *Statistically significant at $p < 0.05$.

Table 3 Surface Roughness Measurements for the ORMCO Orthodontics Bracket

ORMCO Orthodontics Bracket				
Group Name	Treatment	Mean	Std. Dev.	P value
LISTERINE	Control Group	0.9126	± 0.003	
	Experimental 90 Minutes	0.9141	± 0.004	0.3553
	Experimental 7 Days	0.9156	± 0.004	0.0739
OREX	Control Group	0.9126	± 0.003	
	Experimental 90 Minutes	0.9158	± 0.003	0.0283
	Experimental 7 Days	0.9169	± 0.003	0.0049*
Water and Salt	Control Group	0.9126	± 0.003	
	Experimental 90 Minutes	0.9133	± 0.002	0.5469
	Experimental 7 Days	0.9139	± 0.002	0.2692

Notes: *Statistically significant at $p < 0.05$.

and salt (0.9130 μ m) groups. After seven days, the mean (Sa) of the OREX group further increased to 0.9158 μ m, surpassing the values of the other groups. Therefore, the OREX group demonstrated the highest degree of surface roughness compared to all the experimental groups (Table 2).

Similarly, the ORMCO brackets were divided into three subgroups as described in (Table 3): LISTERINE, OREX, and water and salt oral rinse. While surface roughness measurements showed insignificant increases in the 90-minute and seven-day experimental groups, significant differences were observed with the OREX mouthwash group after seven days ($P = 0.0049$). The mean Sa of the OREX group after 90 minutes was 0.9158 μ m, slightly higher than those of the LISTERINE (0.9141 μ m) and water and salt groups (0.9133). After seven days, it rose to 0.9169 μ m, indicating the highest surface roughness among all experimental groups. Therefore, the OREX group demonstrated the highest degree of surface roughness compared to all the experimental groups (Table 3).

In summary, both 3M Unitek and ORMCO Orthodontic brackets underwent testing with LISTERINE and OREX fluoridated mouthwashes, as well as water and salt oral rinse. Minor variations in surface roughness values were observed across all groups. One-way ANOVA analysis revealed statistically insignificant differences in slot roughness, except for the OREX mouthwash groups after seven days, which showed a statistically significant difference with a p-value of ≤ 0.05 (3M Unitek; $P = 0.0454$ and ORMCO; $P = 0.0049$). The highest surface roughness value was observed in the ORMCO bracket group immersed in OREX fluoridated mouthwash, while the least changes in surface roughness were observed in the 3M Unitek group immersed in water and salt oral rinse. Although the difference of approximately 0.004 μ m between groups was statistically significant, its clinical relevance remains uncertain, as such a small change may not meaningfully affect plaque accumulation or bracket performance.

Discussion

The effect of surface roughness in orthodontic brackets is a valuable aspect to study since the rougher surface from the immersion of brackets in oral mouthwashes could affect oral and periodontal health. The increase in bracket surface roughness could negatively affect oral and dental health, promote the adhesion of microorganisms and lead to plaque retention and gingival irritation that can affect periodontal health. Moreover, microorganisms can cause demineralization of the tooth surface around the brackets, which could progress to dental caries.^{4,11,14,21–23} The findings indicate that orthodontic brackets slot surface roughness samples exposed to the fluoridated mouthwash increased, in agreement with previous studies.^{5,8,13} Sodium fluoride mouthwash affects the surface roughness of dental materials, including orthodontic archwire and brackets. However, there is insufficient literature regarding the correlation between stainless steel

orthodontic brackets and sodium fluoride mouthwash, even though other literature shows the association between sodium fluoride mouthwash and the increase in surface roughness in stainless steel orthodontic archwire.^{5,8–10,13,22} Furthermore, sodium fluoride mouthwash was revealed to cause surface roughness with orthodontic materials, including nickel-titanium (NiTi) archwire, titanium brackets, and stainless steel temporary anchorage devices (TAD).^{13,23,24} The changes in the mechanical characteristics of orthodontic electrolytes could be correlated to different factors, for example, the concentration of fluoride ions present in the solution, the duration of immersion in the mouthwash, the acidic pH of the mouthwash solution, and the manufacturing characteristics of the orthodontic brackets.^{25,26} The findings revealed that sodium fluoride mouthwash causes the highest degree of bracket surface roughness. This could be attributed to the presence of acidic and alcohol components in the mouthwash and the low PH of the solution.¹⁵ Furthermore, the findings revealed that OREX mouthwash shows the highest degree of surface roughness in slot brackets, which could contribute to the presence of citric acid in OREX mouthwash and not in LISTERINE mouthwash.²⁷ Interestingly, water and salt oral rinse displayed the lowest degree of surface roughness in all the experimental groups and duration intervals, which is consistent with studies by Botelho et al (2015) and El-Mallakh et al (2021) that tested the effect of water and salt oral rinse in restorative material.^{28,29} Despite the study findings, a significant knowledge gap exists regarding the specific relationship between stainless steel orthodontic brackets and several mouthwash components. Notably, the absence of systematic reviews or meta-analyses on this topic highlights the need for further comprehensive research.

A previous large-scale study on 1200 stainless steel brackets showed that three-months immersion in different mouthwashes resulted in corrosive weight loss, especially in saline (water and salt) and fluoride groups.³⁰ Moreover, a recent scoping review by Makrygiannakis et al (2025) highlighted that regular use of fluoride-containing mouthwashes may promote corrosion and metal ion release from stainless steel and NiTi orthodontic appliances.³¹ It is also important to note that, although the differences in surface roughness reached statistical significance, the absolute change ($\sim 0.004 \mu\text{m}$) is far below the threshold generally considered clinically relevant for microbial adhesion and plaque retention ($0.2\text{--}0.3 \mu\text{m}$), indicating that the observed variations are unlikely to affect bracket performance in practice.³² These studies underscore the continued importance of evaluating mouthwash composition on appliance integrity, supporting the novelty of our current research.

This study has several limitations. First, it used a three-dimensional optical surface profilometer device to test the surface roughness with the arithmetical mean height of a line (Sa); the evaluation of the roughness average (Ra) was not incorporated. Second, microbial adhesion and plaque accumulation tests were not conducted, so clinical implications remain speculative. Third, the mechanical strength of brackets with increased roughness was not evaluated. Finally, pH values of the mouthwashes were not measured.

Conclusions

Immersing stainless steel orthodontic brackets in sodium fluoride mouthwashes, particularly OREX, resulted in a significant increase in surface roughness, likely due to their acidic components. In contrast, water and salt rinse produced the lowest surface roughness, suggesting it may be a safe adjunctive option during orthodontic treatment. Although the differences observed were statistically significant, the small magnitude of change raises questions about their true clinical relevance. To fully clarify the implications of bracket surface roughness, further studies incorporating microbial adhesion tests, pH measurements, and mechanical performance assessments are recommended.

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Disclosure

The authors report no conflicts of interest in this work.

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