ORIGINAL RESEARCH

Impact of Fluoridated and Non-fluoridated Mouth Rinses on Frictional Resistance between Orthodontic Archwire and Bracket: A Comparative Study

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ABSTRACT

Aim and objective: The present study aimed to assess the effect of fluoridated and nonfluoridated mouth rinses on resistance to friction between orthodontic bracket and archwire.

Materials and methods: This study comprises 60 premolar stainless steel (SS) brackets with 0.022 inches slot size. The 0.019 × 0.025 dimensions SS archwires were cut into 5 cm long specimens. They were grouped into three main categories, group I: artificial saliva (control solution), group II: Aloe Dent mouthwash (ALO), and group III: 0.05% sodium fluoride mouthwash. The specimens from each group were either immersed in the test solution or in the control solution for 10 hours. Later, the specimens were transferred to an incubator maintained at 37°C. Post 10 hours, the specimens were immersed for 30 minutes in distilled water. A scanning electron microscope was used to study the surface morphology and a universal testing machine was used to measure the frictional resistance.

Results: The distribution of normality for three study groups’ recorded data was checked using Shapiro–Wilk test. The highest frictional resistance (1.94 ± 0.02) was demonstrated by specimens immersed in 0.05% sodium fluoride mouthwash than those immersed in Aloe Dent mouthwash (1.38 ± 0.66) and artificial saliva (1.10 ± 0.32). The difference found between the groups by an analysis of covariance was statistically significant. The highest surface roughness (22.30 ± 0.12) was revealed by specimens immersed in 0.05% sodium fluoride mouthwash than those immersed in Aloe Dent mouthwash (18.28 ± 0.26) and artificial saliva (15.86 ± 0.42). A statistically significant difference between the groups was shown by an analysis of covariance.

Conclusion: After considering the drawbacks of this study, we conclude that specimens immersed in Aloe Dent mouthwash demonstrated less frictional resistance and surface roughness when compared to those immersed in 0.05% sodium fluoride mouthwash.

Clinical significance: During sliding mechanism, the frictional resistance between orthodontic archwire and brackets imposes problems, such as lessening the applied force and movement of tooth, and also results in anchorage loss. So, orthodontists should always take care while prescribing mouthwashes to reduce their effects on the friction.

Keywords: Archwire, Frictional resistance, Orthodontic bracket, Surface roughness.

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INTRODUCTION

Nowadays, many adult patients are in quest of orthodontic treatment, and there is a growing need for enhanced esthetic quality of orthodontic appliances. This pursuit is partly resolved with the advent of esthetic coated wires and brackets. The success of orthodontic treatment mostly relies on oral hygiene maintenance and prevention of caries.1

Friction is well-defined as the resistance to motion which occurs when solids slide over each other and is of two different types: Static friction and dynamic friction. Static friction happens during the start of factual sliding motion, whereas dynamic friction happens during motion. The friction resistance develops between bracket and archwire during tooth movement phases in orthodontics. Some biological and mechanical aspects can impact friction in orthodontics. The biological aspects involved are dental plaque accretion and saliva, while mechanical aspects include bracket and wire properties and ligation methods.2

The orthodontic treatment process gets adversely affected by frictional force which diminishes or prevents tooth movement resulting in anchorage loss. As per earlier studies, the sliding friction decreases the applied force equal to 50%.3,4 Although not practical, total elimination of this frictional force is ideal. Data related to the significant factors permit the control of sliding resistance. Several factors impact the approximation of friction rates, such as bracket

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and wire material, their size, oral environmental factors, ligation type, surface characteristics, and magnitude and direction of force. The oral environment is not a passive setting and discloses the orthodontic appliances to dissimilar materials.5

The success of orthodontic treatment relies on good oral hygiene; thus, orthodontists should recommend patients to regularly use dentifrices and mouthwash to protect against dental plaque accumulation and caries. Nevertheless, the ingredients of mouthwash may enhance the corrosion of both nickel titanium (NiTi) and stainless steel (SS) archwires. The herbal mouthwashes which are nonfluoridated have been introduced for oral hygiene maintenance using the healing and natural cleansing properties of herbs for gingiva and teeth. Additionally, it does not contain any chemical compounds or alcohol. Moreover, herbal mouthwashes do not have any side effects because of their natural ingredients.5 Therefore, this study was conducted to measure the impact of nonfluoridated and fluoridated mouth rinses on frictional resistance between orthodontic archwires and bracket.

**Materials and Methods**

The present study was conducted in the Department of Orthodontics, Purvanchal Institute of Dental Sciences, India. This study comprises 60 premolar SS brackets (Roth, Leone, Italy) with 0.022 inches slot size. The dimensions of SS archwires were 0.019 × 0.025 (Ortho-organizer, USA) and were cut into 5 cm long specimens, and elastomeric modules (O-Tie 120 diameter latex-free, Ortho-organizer, USA) were used to ligate each specimen. They were separated into three main groups:

**Group I:** Artificial saliva (control solution) with a pH of 7 containing 0.5% w/v methylcellulose and 30% w/v glycerin per 5 mL of solution (ICPA Health Products Ltd., 286 GIDC, Ankleshwar). **Group II:** Aloe Dent® mouthwash (Aloe Vera mouthwash, Optima®, Italy) composed of natural Aloe Vera ingredient aqua, natural constituent of essential oils with a pH of 5.17. **Group III:** Sodium fluoride mouthwash (0.05%) of pH 6 (Oral-B, Procter and Gamble Strasse, Gross-Gerau, Germany) was used for assessing the effect of fluorides.

Twenty specimens each were immersed in the both test and control solution for 10 hours. Later, the specimens were transferred to an incubator maintained at 37°C. Post 10 hours, the specimens were kept for 30 minutes in distilled water. In order to eliminate the effect of various elastomeric forces on the findings, the dried wires along with brackets were engaged with elastomeric modules (O-Tie 120 diameter latex-free, Ortho-organizer, USA).

**Evaluation of Surface Roughness**

A scanning electron microscope (SEM) was used to estimate bracket slot surface roughness in all the specimens, after it is being immersed in different solutions. Distilled water was used to wash the brackets. Afterward, a two-sided tape with carbon adhesive was used to mount the sample on a holder. Post this, the specimens were taken to the SEM’s vacuum chamber where specimens were

| Group I: Artificial saliva (n = 20) | Group II: Aloe Dent mouthwash (n = 20) | Group III: 0.05% sodium fluoride mouthwash (n = 20) |
|-----------------------------------|----------------------------------------|-----------------------------------------------|
| Frictional resistance | Z | p value | Z | p value | Z | p value |
| Frictional resistance | 0.6898 | 0.924 | 1.020 | 0.246 | 0.8230 | 0.586 |

Z, standard score; p, probability value

Air dried. All the specimens were thoroughly viewed under ×1,000 magnification at 20 kV. And analysis was performed in Purvanchal Institute of Dental Sciences, India.

**Evaluation of Frictional Resistance**

A universal testing machine maintained at 25°C room temperature in the dry state was used to measure friction; segment of SS wire was positioned with module in mounted bracket slot at 25 mm from the bottom end of the archwire to create a test unit. Later, the complete bracket-wire assemblage with the template mounting was then held straight up in the lower jaws of the Instron Universal Testing Machine which was floor mounted. The free top end of the archwire was supported by the Instron Universal Testing Machines upper jaws and the machine was coupled to the load cell.

The calibrations of the 10 N load cell ranged from 0 to 10 N, the machine was customized in the tensile mode and the archwires were drawn through the brackets as the cross-head moved up at 10 mm/minute rate of through 5 mm distance. The universal testing machine evaluated the tensile force needed to pull the wire through fixed bracket, along with tracking distance as a numerical read out in lengths in terms of millimeter as the cross-head moved above the wire. Likewise, friction was evaluated and recorded for all the 60 test units. Each bracket was analyzed only once and each wire specimen was drawn through one bracket only, to eradicate the impact of wear and the average was recorded. All the tests were performed in dry conditions at room temperature.

**Statistical Analysis**

The normality of the data was tested using Shapiro–Wilk test and SPSS software (version 20.0) was used for statistical analysis. The data between groups were described using mean and standard deviation. One-way ANOVA test, followed by post hoc analysis was used to examine the friction resistance’s significance and immersed groups’ surface roughness. A p value <0.05 was considered statistically significant.

**Results**

The distribution of normality for three study groups’ recorded data was checked using Shapiro–Wilk test as shown in Table 1. As the data were found to be distributed normally, the parametric test of ANOVA (one-way) was used.

The comparison of frictional resistance of specimens after being immersed in three dissimilar mouth rinses is as displayed in Table 2. The highest frictional resistance (1.94 ± 0.02) was shown by sodium fluoride mouthwash (0.05%) when compared to Aloe Dent mouthwash (1.28 ± 0.66) and artificial saliva (1.10 ± 0.32). The difference demonstrated by analysis of covariance between the groups was statistically significant. Tukey’s post hoc analysis showed pair-wise assessment between 0.05% sodium fluoride mouthwash and artificial saliva and, between 0.05% sodium fluoride mouthwash and Aloe Dent mouthwash to be significant statistically.
The comparison of surface roughness of specimens immersed in different mouth rinses is as shown in Table 3. The highest surface roughness (22.30 ± 0.12) was demonstrated by 0.05% sodium fluoride mouthwash as compared to Aloe Dent mouthwash (18.28 ± 0.26) and artificial saliva (15.86 ± 0.42). A statistically significant difference was demonstrated by analysis of covariance between the groups. A significant pair-wise comparison (p < 0.001) was shown by Tukey’s post hoc analysis between artificial saliva and 0.05% sodium fluoride mouthwash and Aloe Dent mouthwash.

**Discussion**

The consequences of orthodontic treatment depend largely on how efficiently the forces and the subsequent reactions are managed. On using sliding mechanics in orthodontics, friction develops between archwire and brackets and this has the most important effect on the force eventually distributed to teeth. The factors that influence the frictional resistance between brackets and archwire generally differs with archwire material and size, method of ligation, width of bracket, wire angulations to bracket, and environmental and biological aspects, such as bacterial plaque, saliva, attained film, and corrosion.⁷

For improved relationship between the outcomes of experimental situation and the friction test, intraoral dynamics model is beneficial. Thus, during the procedures to test friction, the presence of lubricants will assist as a significant feature as saliva plays a role in *in vivo* mechanism of sliding. Several tests for friction have been performed in dry or parched conditions, though few trials based their tests using artificial saliva as a medium.⁸,⁹
Various trials on resistance to friction using saliva led to diverse outcomes. Choudhary et al. explained the resistance to friction in the parched condition and wet or damp state with saliva in which brackets made up of polycrystalline alumina and SS were compared to wires made up of NiTi, SS, cobalt chromium, and beta-titanium and the dynamic or kinetic friction was found to be reduced for each SS combination, while it was found to be improved for each combination of beta-titanium in the parched condition. In contrast, the friction was found to be reduced equal to half (50%) for every combination of beta in the damp condition. The fluctuating outcome of resistance to friction in the damp and parched conditions is central to explain the consequence of the medium used for testing on the resistance to friction.

In the present study, the mean frictional resistance of specimens immersed in Aloe Dent mouthwash is less than those of specimens immersed in sodium fluoride mouthwash. The maximum frictional resistance of NaF immersed specimens could be ascribed to the fluoride ions that cause the decay of protective layer of wire and increase its solubility. These results are similar to those obtained by Heravi et al. Friction resistance was found to be less in specimens immersed in artificial saliva than those immersed in NaF mouthwash and this finding is in accordance with results obtained by Geramy et al. and Kao et al. Additionally, the results demonstrate a non-significant difference of frictional resistance of specimens between artificial saliva and Aloe Dent mouthwash. This may possibly be credited to the antioxidative property of natural phytochemical herbs which may avoid diffusion of oxygen into the surface of archwire. Consequently, the antioxidative property of these mouthwash ingredients may prevent passive layer degradation of the archwire. Trials by Nanjundan and Vimala, and Alavi and Farahi demonstrated that fluoridated mouthwashes increased the frictional resistance of SS wires, the findings being similar to those obtained in the present study.

The SEM was used to examine the bracket slot and the photomicrographs of the immersed brackets showed multiple small pits in Aloe Dent mouthwash, extreme heterogeneous patchy area in sodium fluoride mouthwash, and little pits in artificial saliva. Nevertheless, comparable vertical crack lines were seen in all SEM photomicrographs. The diverse patchy area in the bracket’s slot surface immersed in sodium fluoride mouthwash may be accredited to the breakdown of passive layer of chromium oxide due to the impact of fluoride ion leading to chromium fluoride formation. This is in accordance with results gained by Schiff et al. who demonstrated changes in surface texture of metal bracket’s slot immersed in fluoride mouthwash under SEM examination and these can be attributed to the damage of passive layer of chromium oxide under the impact of fluoride ions. In contrast, brackets that were immersed in artificial saliva exhibited smaller pits and a more consistent slot surface. This is similar to the findings of Lin et al. who noticed smaller pits with vertical cracks on the SS bracket’s slot surface which was immersed in artificial saliva.

The resistance to friction depends on several parameters and is sensitive to the procedure used, and so a single trial can have different findings based on varied clinical conditions and different clinicians. An in vitro setting research may not be similar to an experiment with an in vivo environment. Intraoral temperature, form of the arch, its angulations, dental plaque, force of mastication, pH of saliva, and the alternating occlusal forces could impact the static frictional force and provide fluctuating results.

**Conclusion**

After considering the drawbacks of this study, we conclude that specimens immersed in Aloe Dent mouthwash demonstrated less frictional resistance and surface roughness when compared to those immersed in 0.05% sodium fluoride mouthwash. Thus, nonfluoridated mouthwash can be used as an alternative to fluoridated mouthwash to aid in oral hygiene in patients undergoing orthodontic treatments.

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