Does presence of alcohol in mouthwash have any effect on frictional resistance of Nickel Titanium and Stainless Steel archwires ? - An Invitro Study.

Dr. Ankita Jadhav[1], Dr. Shivpriya Aher[2], Dr. Mukul Tambe Patil[3], Dr. Nitin Gulve[4], Dr. Amit Nehete[5] , Dr. Ravisha Salve[6] .

Second year post graduate[1], Professor[2], Professor[3], Head of Department[4] , Professor[5] , Professor[6]. Department of Orthodontics and Dentofacial Orthopaedics, MGV's KBH Dental College and Hospital, Nashik - 422003, Maharashtra, India.

mdsankita@gmail.com[1], drshivpriyaaher@gmail.com[2] , drmukultambe@gmail.com[3], nashikdentist@gmail.com[4] , dramit0202@gmail.com[5] , drravishasalve@gmail.com[6] .

Scientific motivation-

Frictional resistance affects the predictability of orthodontic treatment outcomes. Excessive friction can lead to unpredictable tooth movement, compromising the orthodontist's ability to achieve precise and desired results. By understanding and minimizing frictional resistance, orthodontists can optimize the efficiency of tooth movement during orthodontic treatment. Reduced frictional forces allow for smoother and quicker tooth alignment, reducing treatment duration.

The general significance of the obtained results-

In summary, studying frictional resistance of archwires in orthodontics is crucial for achieving efficient, predictable, and comfortable tooth movement during orthodontic treatment. It allows orthodontists to optimize treatment outcomes, improve patient experience, and advance the field through material innovations.

ABSTRACT :

Aim: The aim of this study was to evaluate and compare the effect of alcohol-containing mouthwash and alcohol-free mouthwash on frictional resistance of Nickel-Titanium and Stainless Steel orthodontic arch wires.

Methods: A total of 40 extracted premolars mounted on a custom- made acrylic jig were randomly divided into 4 groups of 10 sample each, on which 0.019″ × 0.025″ nickel- titanium and stainless steel arch wires were ligated.Two experimental groups were immersed in Alcohol containing mouthwash (LISTERINE® COOLMINT) and two in Alcohol free mouthwash (COLGATE PLAX® FRESHMINT), for 1 hour respectively. Post- immersion static frictional resistance was evaluated on a universal testing machine at crosshead speed of 1mm/min.0ne way ANOVA and Post-hoc Tukey tests were used to compare the groups.

Results: This study showed a statistically significant difference in the frictional resistance between alcohol containing and alcohol free groups. ($P < 0.05$). The frictional resistance was more in the Alcohol containing mouthwash group than the Alcohol free mouthwash group. However, no significant difference was observed in the frictional resistance between the Niti and SS archwire groups.

Conclusion: Within the experimental conditions/limitations of this in vitro study, it can be concluded that the presence of alcohol in mouthwash does affect the frictional resistance of Nickel Titanium and Stainless Steel archwires. Based on this result, alcohol-free mouthwash can be used instead as an oral hygiene aid in patients with orthodontic treatments.

KEYWORDS: Orthodontic archwire, Nicket titanium, Stainless steel, Friction, frictional resistance, alcohol, mouthwash.

INTRODUCTION:

During orthodontic treatment, wires and brackets bonded to teeth create retention zones that are difficult for patients to clean. Mouth rinses are recommended for patients along with mouthwashes to establish healthier oral hygiene. While these mouthwashes have undeniable benefits, they can also increase friction and cause reduced tensile strength and microhardness by altering the mechanical and surface properties of archwires, brackets, and other auxiliaries.[1]

Friction is well defined as the resistance to motion that occurs when solids slide over each other, and is of two different types: Static friction and dynamic friction. Static friction occurs at the beginning of the actual sliding motion, whereas dynamic friction occurs during the sliding motion.[2] Friction in orthodontics occurs at multiple contact points along the archwire. The variables affecting friction between fixed appliance components include brackets, archwires, ligation mechanisms, and biological factors.[3]

During the orthodontic tooth movement phase, frictional resistance is created between the brackets and the archwire. Several biological and mechanical aspects have effect on friction in orthodontics. Biological aspects include plaque and saliva accumulation, while mechanical aspects include bracket, wire properties and ligation methods.

Successful orthodontic treatment depends on good oral hygiene. Therefore, orthodontists should encourage patients to use toothpaste and mouthwash regularly to protect against plaque and cavities. However, mouthwash ingredients can affect the properties of nickel-titanium (NiTi) and stainless steel (SS) archwires.[2]

Mouthwashes available in the market include a number of alcohol containing and alcohol free mouthwashes. The alcohol used in mouthwash is usually ethanol. The alcohol in mouthwash is used as a solvent for various active chemicals. It also acts as a preservative and active ingredient up to a concentration of 12%. In the case of various side effects from using alcohol-based mouthwashes, many alternative medicine practitioners recommend using alcohol-free mouthwashes.The alcohol-free mouthwashes which are commonly recommended are mouthwashes containing active ingredients such as chlorohexidine gluconate, cetylpyridinium chloride, and essential oils.[4-7]

Although there have been numerous studies on various mechanical properties of arch wires, little is known about the effects on the frictional resistance of arch wires after treating with mouthwashes. Therefore, this study was conducted to measure the impact of alcohol-containing and alcohol-free mouthwashes on the frictional resistance of Ni-Ti and SS arch wires.

MATERIAL AND METHODS:

The study was conducted on 40 extracted premolars in the Department of Orthodontics and Dentofacial Orthopaedics. Alcohol containing mouthwash and Alcohol free mouthwash were used for this study.

Based on the following inclusion and exclusion criteria, the samples were selected -

Inclusion Criteria:

1. Teeth free of caries/restorations
2. Non-hypoplastic teeth
3. Teeth free of dental wears, fractures, and structural abnormalities

Exclusion Criteria:

1. Carious and restored teeth
2. Attrited teeth
3. Fractured teeth and teeth with dental anomaly
4. Teeth with iatrogenic damage

The total sample was further divided into the following 4 groups-

1. Group 1: Experimental group (EG) composed of 10 samples of 0.019″ × 0.025″ SS wires immersed in Alcohol-containing mouthwash for an hour (equivalent to 4 weeks daily oral rinsing, 1 minute for each rinsing, two times a day)
2. Group 2: Experimental group (EG) composed of 10 samples of 0.019″ × 0.025″ NiTi wires immersed in Alcohol-containing mouthwash for an hour.
3. Group 3: Experimental group (EG) composed of 10 samples of 0.019″ × 0.025″ NiTi wires immersed in Alcohol-free mouthwash for an hour.
4. Group 4: Experimental group (EG) composed of 10 samples of 0.019″ × 0.025″ SS wires immersed in Alcohol-free mouthwash for an hour.

Specimen Preparation:

The crowns of the selected samples were cleaned with pumice and mounted in a custom- made acrylic jig. The acrylic jig, formed of specific dimension were fixed to the universal testing machine (INSTRON Universal Testing Machine,India). After which, brackets were bonded at the center of the crown of the teeth mounted in the acrylic jig. All the samples (n = 40) were etched with etchant (37% phosphoric acid gel) for 30 seconds,washed and dried with oil- free compressed air. The brackets were then bonded with adhesive Transbond XT and 3M Unitek primer and cured using light- emitting diode light with a curing cycle of 30 seconds. A 0.019″ × 0.025″ stainless steel arch wire and 0.019″ × 0.025″ Nickel Titanium arch wire was cut into 5- cm long segments respectively. These segments were tied on to the bracket with the help of a ligature wire to form a Test unit. After which, the samples were divided into the aforementioned 4 groups and then immersed in their respective mouthwash solutions for an hour.

Figure 1. Test Unit with 5mm archwire ligated with ligature wire

Figure 2. to Figure 5. Ten samples each immersed in their respective mouthwash for an hour , divided in 4 groups

Frictional Resistance Evaluation:

The specimens were removed from their respective mouthwash solutions after an hour, and INSTRON universal testing machine was used to measure the frictional force. The universal testing machine was attached to the upper end of the wire of the test unit. The load cell was calibrated at 25 KN.

Figure 6. Instron Machine

At a crosshead speed of 0.5mm/min,the wire was pulled and the data was transferred to a computer connected to the machine. Each of the 40 samples were tested for static friction, which is the maximum frictional force required to generate the initial movement of the bracket over five millimeters.

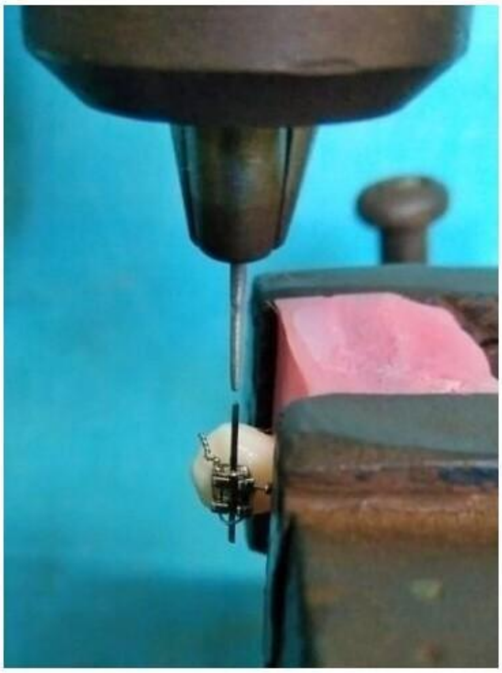

Figure 7. The wire was pulled, at a crosshead speed of 0.5mm/min; 25kN force.

Statistical Analysi:

A statistical analysis of the obtained data for the four experimental groups was performed using statistical package for social science software (SPSS), version 24.0 (SPSS Inc., Chicago, IL, USA), with a statistical significance level of $p < 0.05$.The significant differences among the mean static friction values of the four groups were determined using One- way analysis of variance (ANOVA). To determine which of the mean values were significantly different from each other, Tukey's post hoc comparison test was used.

RESULTS:

Table 1 depicts the descriptive statistics including mean, standard deviation(SD), and standard error(SE) of frictional resistance. Group I had the highest statistical frictional resistance as compared to group II,III and IV. Group III had the lowest statistical frictional resistance as compared to group I,II and IV.

	Mean	SD	SE	Minimum	Maximum
Group I (Alcohol containing M/w-SS wires)	6.13	2.07	0.65	3.4	10
Group II (Alcohol containing M/w-NiTi wires)	6.07	1.35	0.43	4.5	8.8
Group III (Alcohol free M/w-NiTi wires)	3.84	1.73	0.55	2.4	8
Group IV (Alcohol free M/w-SS wires)	4.66	1.23	0.39	2.5	6.2

Table 1: Descriptive statistics of static frictional resistance values of each group.

As shown in Table 2, the results of the One-way ANOVA showed a statistically significant difference ($P < 0.05$) in frictional resistance among the four study groups ($P < 0.05$).

	Mean	SD	One way Anova F test	P value, Significance
Group I (Alcohol containing M/w-SS wires)	6.13	2.07		
Group II (Alcohol containing M/w-NiTi wires)	6.07	1.35		

Group III (Alcohol free M/w-NiTi wires)	3.84	1.73	4.73466	0 .006943*
Group IV (Alcohol free M/w-SS wires)	4.66	1.23		

Table 2: Overall Comparative statistics of static frictional resistance values using One way Anova F test

Tukey's post hoc procedure showed pairwise comparison in between alcohol-containing and alcohol-free mouthwash for Ni-Ti arch wires and SS arch wire groups with respect to frictional resistance as depicted in Table 3. This study showed a statistically significant difference in the frictional resistance between Group I and Group III and also in Group II and Group III ($P < 0.05$). There was no statistically significant difference between the rest of the groups (P >0 .05).

Tukey's post hoc test for pairwise comparison			
Group	Comparison Group	Mean Difference	P value, Significance
Group I (Alcohol containing M/w-SS wires) Vs	Group II (Alcohol containing M/w - NiTi wires)	0.06	p>0.05
	Group III (Alcohol free M/w -NiTi wires)	2.29	p<0.05*
	Group IV (Alcohol free M/w-SS wires)	1.47	p>0.05
Group II (Alcohol containing M/w-NiTi wires) Vs	Group III (Alcohol free M/w -NiTi wires)	2.23	p<0.05*
	Group IV (Alcohol free M/w-SS wires)	1.41	p>0.05

Group III (Alcohol free M/w-NiTi wires) Vs	Group IV (Alcohol free M/w-SS wires)	0.82	p>0.05
p>0.05 – no significant difference *p<0.05 – significant **p<0.001 – highly significant			

Table 3: Pairwise Comparative statistics of frictional resistance values using Tukey's post- hoc test

The frictional resistance was more in the Alcohol containing mouthwash group than the Alcohol free mouthwash group. However, no significant difference was observed in the frictional resistance between the NiTi and SS groups.

DISCUSSION:

In the present study, the effects of alcohol containing and alcohol free mouthwashes on the frictional resistance of NiTi and SS archwires were evaluated.

When one body slides over another, friction is experienced. The bracket moves in a series of steps rather than in a smooth continuous motion, during the sliding mechanics. Friction is affected by several parameters such as wire stiffness, its roughness and hardness, material, medium of fluid, and surface chemistry at the bracket and archwire interface. Numerous studies have been conducted to investigate the parameters that influence friction. However, the use of prophylactic mouthwash and the effect of alcohol on friction have not been well studied. Therefore, the purpose of this study was to evaluate the effects of two different mouthwashes on frictional resistance of NiTi and SS archwires. The mouthwashes used in this study were Alcohol containing- Listerine and Alcohol free- Colgate plax. The archwires used were 0.019″ × 0.025″ Nickel Titanium and 0.019″ × 0.025″ Stainless steel wires. Listerine® is an alcohol-based mouthwash (including: thymol 0.064%, menthol 0.042%, eucalyptol 0.092%, methyl salicylate 0.060%) dissolved in water-ethanol solvent. Colgate Plax® is an alcohol-free, antibacterial mouthwash composed of Camellia Sinensis Leaf Extract, Menthol, Propylene Glycol, Sorbitol, Sodium Saccharin, Cetylpyridinium Chloride, and Potassium Sorbate.

Orthodontic treatment requires long-term use of anti-plaque and anti-gingivitis agents. Long-term use of mouthwash in orthodontic patients only emphasizes understanding the action of mouthwash at the bracket-archwire interface and how it affects the sliding mechanism.5 In this study,the frictional resistance was more in the Alcohol-containing mouthwash group than the Alcohol-free mouthwash group. However, no significant difference was observed in the frictional resistance between the NiTi and SS groups.

One explanation for the reduced frictional resistance seen with alcohol free mouthwash can be explained with the fact that Camellia sinensis leaf extract, the basic constituent has a hydrocarbon backbone, has a high lubricant property. It is rich in bioactive compounds, such as catechins, L-theanine, and caffeine, and studies have linked it to multiple beneficial effects.This could lead to a reduced resistance seen between the bracket and archwire.

However, frictional resistance is affected by several factors. The precise interactions that occur at the bracket-archwire interface with the use of mouthwash should be investigated. The comparative evaluation shows that alcohol free mouthwash is a better choice over alcohol containing mouthwash.[8]

Patients undergoing orthodontic treatment may be advised to use alcohol-free mouthwashes to maintain oral hygiene. Orthodontists can be more selective and careful in choosing the type and brand of mouthwash to be used for orthodontic treatment.[9,10]

CONCLUSION:

Within the experimental conditions/limitations of this in vitro study, it can be concluded that the static frictional resistance was more in the alcohol-containing mouthwash group than in the alcohol-free mouthwash group. Thus, the presence of alcohol in mouthwash affects the frictional resistance of Nickel Titanium and Stainless Steel archwires.

Based on this result, alcohol-free mouthwash can be used instead as an oral hygiene aid in patients with orthodontic treatments.

ACKNOWLEDGEMENT:

The authors are thankful to MGV KBH's Dental College and Hospital, Nashik for giving a platform to conduct the study.

REFERENCE:

1. Nalbantgil D, Ulkur F, Kardas G, Culha M. Evaluation of corrosion resistance and surface characteristics of orthodontic wires immersed in different mouthwashes. *Biomed Mater Eng.* **2016**;27*(5)*:539-49.
2. Mahajan V, Singla A, Negi A, Jaj HS, Bhandari V. Influence of alcohol and alcohol-free mouthrinses on force degradation of different types of space closure auxiliaries used in sliding mechanics. *J Ind Orthod Soc*. **2014**;48:546-51.
3. Prashant PS, Nandan H, Gopalakrishnan M. Friction in orthodontics. *J Pharm Bioallied Sci*. **2015**;7:S334-8.
4. Choudhary J, Shashikumar B, Patil AK. Evaluation and comparison of two different mouthwashes on frictional resistance between orthodontic bracket and archwire: An in vitro study. *J Ind Orthod Soc*. **2019**;53*(2)*:117-25.
5. Arweiler NB, Netuschil L, Reich E. Alcohol- free mouthrinse solutions to reducesupragingival plaque regrowth and vitality: A controlled clinical study. *J Clin Periodontol*. **2001**;28*(2)*:168-74.
6. Omidkhoda M, Sahebnasagh Z, Poosti M, Yaghoobi M, Izadpanahi A. Evaluation of mechanical properties of NiTi orthodontic wire after immersion in three different mouthwashes. *Iran J Orthod*. **2011**;6*(3)*:32-8.
7. Aghili H, Yassaei S, Eslami F. Evaluation of the effect of three mouthwashes on the mechanical properties and surface morphology of several orthodontic wires: An in vitro study. *J Dent Res*. **2017**;14*(4)*:252.
8. Namita P, Mukesh R, Vijay KJ. Camellia sinensis (green tea): a review. *Glob J Pharmacol*. **2012**;6*(2)*:52-9.
9. Santana W, Thahar B, Mardiati E, Salim J. The effect of alcoholic mouthwash, non-alcoholic mouthwash and artificial saliva towards the power chains force decay. *Padjadjaran J Dent*. **2017**;29*(3)*:195-201.
10. Jamilian A, Moghaddas O, Toopchi S, Perillo L. Comparison of nickel and chromium ions released from stainless steel and NiTi wires after immersion in Oral B®, Orthokin®and artificial saliva. *J Contemp Dent Pract*. **2014**;15*(4)*:403-6.