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Comparative evaluation of four different mouthwashes on frictional resistance between the orthodontic bracket and arch wire – An in vitro study

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Abstract

Aim and Objective: To evaluate and compare frictional resistance between orthodontic bracket and arch wire in four different mouthwashes.

Methods: 100 natural teeth were individually mounted in acrylic block and divided into 5 groups consisting of 20 teeth in each group. The 5 oral rinses used are Artificial saliva, Tea Tree oil, Tea Tree oil with coconut oil, Chlorhexidine, Phosflur. The enamel surfaces were cleaned and etched. Primer was applied and 3M Unitek brackets were bonded to each tooth and cured. 50mm length of 19×25 Stainless steel straight arch wire was ligated individually to all the brackets. The specimens were immersed in Artificial saliva and Tea Tree oil, Tea Tree oil with coconut oil, Chlorhexidine, Phosflur mouthwashes for 1.5 hours. The arch wire was pulled through the bracket at 0.5mm/min crosshead speed with 5N load and the frictional resistance was measured using Universal testing machine.

Results: The Mean value of Phosflur group had the highest score. The least score was found in Artificial saliva group followed by Tea Tree oil. Tea tree oil had significant difference with all the groups except Artificial saliva.

Conclusion: Tea tree oil mouthwash showed least values of frictional resistance when compared to Phosflur, Chlorhexidine and Tea Tree oil with coconut oil mouthwash.

Keywords: Frictional resistance, Mouthwash, Tea Tree oil, Sliding mechanics.

Introduction

Tooth movement is the combination of friction and physiology. Whenever arch wire slides through the bracket slot, friction is encountered at interface, in a direction tangent to the involved bracket and wire.[1]

Size and material of the bracket and wire, angulation between them, inter-bracket distance, material & method of ligation, surface characteristic, magnitude & direction of force and oral environment and several other factors affect friction.

It is important to reduce the friction as low as possible to obtain optimum biological response and achieve optimum tooth movement. As the friction is affected by mouthwashes, correct recommendation of mouthwash is pivotal. They can affect the surface characteristics and mechanical properties of the appliance.

Chlorhexidine is an antiseptic, anti-plaque and anti-microbial mouthwash. It has numerous side effects like taste sensation impairment, staining of teeth on long term, also known to show effect on friction. Several investigations showed contradicting results on frictional resistance with chlorhexidine mouthwash.

Fluoride mouthwashes are used for the prevention of decay and white spot lesion. The ions released tend to alter the mechanical properties of orthodontic appliance. Previous studies showed that frictional resistance was higher with higher concentrations of fluoride.

Recently, the use of herbal mouthwash has gained interest as they are free of chemicals and are safe to use.[2] A non-fluoridated Tea tree oil mouthwash which is extracted from melaleuca alternifolia.[3] They naturally have good antiseptic, antibacterial and antifungal effect. Many recent studies have confirmed that the frictional values are less with tea tree oil mouthwash [2]

Hence this in vitro study was attempted to evaluate and compare the frictional resistance between bracket and arch wire in artificial saliva, Tea tree oil mouthwash, Tea tree oil with coconut oil mouthwash, Chlorhexidine and Phosflur mouthwash.

Materials and methods

Sample selection

The study sample consisted of 100 natural premolar teeth that were recently extracted for orthodontic purpose. The teeth were collected based on following exclusion criteria.

Exclusion criteria

The teeth with following defects were excluded,

a) Dental Caries
b) Hypoplasia/ Fluorosis
c) Restoration
d) Enamel cracks
e) Developmental Anomalies

Sample distribution

100 teeth were collected and stored in 10% formalin solution. All teeth were individually mounted on a custom-made acrylic block (Figure 1) made using a rubber mould. The acrylic block is made of specific dimension for accurate fixation to the universal testing machine. All the acrylic blocks with a tooth in it are split into 5 groups namely Group A, Group B, Group C, Group D, Group E composing of 20 teeth in each group.

They were colour coded (Figure 2) with a tape over acrylic block to prevent investigator bias as following.

Group A – Blue

Group B – Pink

Group C – Orange

Group D – Green

Group E – Brown

Figure 1: Tooth mounted in acrylic block

Figure 2: colour coded into 5 groups

Methodology

The research protocol was approved by the Ethical Committee of the Institution.

The enamel surface of the teeth was thoroughly cleaned with the pumice using a polish brush cup in a contra-angle hand piece. 37% Ortho-phosphoric acid – Scotch bond 3M was applied on the labial surface of all the teeth for 30 seconds. Distilled water was used to rinse the etchant and the teeth were air dried until a white frosty appearance was obtained.

A primer Trans bond XT Primer – 3M Unitek was applied over the etched surface using blotting technique. The Premolar brackets with 0.022" slot MBT prescription (3M Unitek Gemini) were bonded with Trans bond XT (3M Unitek) adhesive and light cured using blue phase N MC (Ivoclar Viv dent). 19×25 SS (G & H) straight arch wire of length 50mm was ligated individually to all the brackets bonded to the tooth using 3M elastomeric modules (Figure 3).

Figure 3: Test specimen, 19×25 SS ligated to the brackets

The arch wire ligated specimens were immersed in their respective solutions for 1.5 hours in a glass beaker (Figure 4). 1.5 hours is chosen to simulate 30seconds of using oral rinse twice daily for 3 months [4].

Figure 4: Immersed in respective solution for 1.5 hours

Grouping: (Figure 4)

Group A - Artificial saliva (Diagnostic reagent, B.N. Laboratories)

Group B - Tea Tree Oil (Desert Essence)

Group C - Tea Tree with coconut oil (Desert Essence)

Group D - Chlorhexidine (Chlordent)

Group E – Phosflur (Colgate Ortho Defence)

Figure 5: Five oral rinses used in the study

Frictional resistance evaluation

After 1.5hrs of immersion the sample units were taken out from their solutions and frictional resistance was measured using INSTRON universal testing machine (Figure 6). The test unit is placed in such a way that they are parallel to the vertical framework of the universal testing machine and the upper end of the arch wire is attached to the machine. The arch wire is pulled through the bracket at 0.5mm/min crosshead speed with 5N load. Care is taken to avoid administering torsion to the samples. Static friction generated between the bracket and wire is measured by the machine. All the data are transferred to the computer.

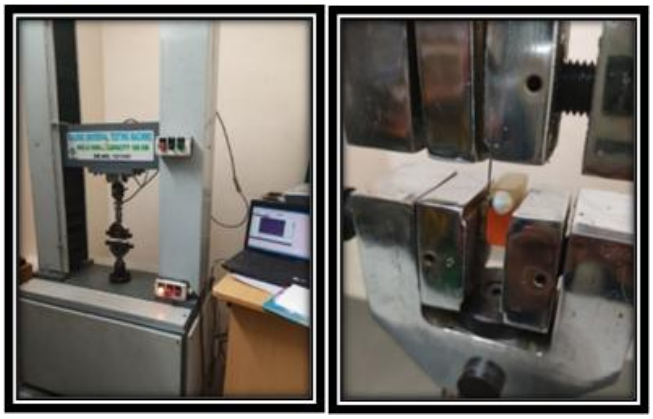

Figure 6: Universal testing machine (measuring frictional resistance)

Statistical analysis

The data collected were compiled using MS-Office Excel and was subjected to statistical analysis using IBM corp. All analysis were performed using SPSS software 26.0 version. Descriptive and inferential statistics were used to analyse the data. The results were presented as Mean, Standard Deviation and Interquartile range for continuous data. Assessment for the Normality of the data was done using Shapiro-Wilks test. One way ANOVA test was done to compare difference between groups. Based on the distribution of the data, Post Hoc Tukey's test was carried out to analyse Pairwise Comparison between groups. Difference in frictional resistance between tea tree oil and other groups was compared individually by Unpaired t-test.

Results

Table 1 shows one way ANOVA that compared Mean score between the groups. There is a statistically significant difference in the scores when compared between the groups ($p<0.05$). The Mean of Phosflur group has the highest score followed by Tea Tree with Coconut oil group. The least score was found in Artificial saliva group followed by Tea Tree oil.

Table 1: Mean and standard deviation of frictional resistance of all groups.

Group	N	Mean	Std. Deviation	P value
Artificial saliva	20	1.1861	.69454	.000*
Tea tree oil	20	1.9673	.50937	
Tea tree with coconut oil	20	3.1045	1.05333	
Chlorhexidine	20	2.9849	1.15112	
Phosflur	20	3.4476	1.02719	
Total	100	2.5381	1.23267	

*One way ANOVA $p<0.05$

Table 2 shows Pair wise comparison between the groups. Tea tree oil had significant difference with all the groups except Artificial saliva. Tea tree oil with

Coconut oil had significant difference with Artificial saliva and Tea tree oil. Chlorhexidine and Phosflur also showed Significant difference with Artificial saliva and Tea tree oil.

Table 2: pair wise comparison between the groups.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Tea tree oil	Artificial saliva	.78125	.29091	.064	-.0277	1.5902
	Tea tree with coconut oil	-1.13725*	.29091	.002	-1.9462	-.3283
	Chlorhexidine	-1.01760*	.29091	.006	-1.8266	-.2086
	Phosflur	-1.48025*	.29091	.000	-2.2892	-.6713
Tea tree with coconut oil	Artificial saliva	1.91850*	.29091	.000	1.1095	2.7275
	Tea tree oil	1.13725*	.29091	.002	.3283	1.9462
	Chlorhexidine	.11965	.29091	.994	-.6893	.9286
	Phosflur	-.34300	.29091	.763	-1.1520	.4660
Chlorhexidine	Artificial saliva	1.79885*	.29091	.000	.9899	2.6078
	Tea tree oil	1.01760*	.29091	.006	.2086	1.8266
	Tea tree with coconut oil	-.11965	.29091	.994	-.9286	.6893
	Phosflur	-.46265	.29091	.507	-1.2716	.3463
Phosflur	Artificial saliva	2.26150*	.29091	.000	1.4525	3.0705
	Tea tree oil	1.48025*	.29091	.000	.6713	2.2892
	Tea tree with coconut oil	.34300	.29091	.763	-.4660	1.1520
	Chlorhexidine	.46265	.29091	.507	-.3463	1.2716

Table 3 shows Post Hoc Tukey's test, Comparing Artificial saliva with other groups. The mean value of Artificial saliva when compared with Tea tree oil did not show statistically significant (p=0.064) difference. But there was a statistically significant (p= .000) difference between mean value of artificial saliva in comparison with tea tree oil & coconut oil, Chlorhexidine and Phosflur (Table 4).

Table 3: comparison of artificial saliva with other groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Significance
Artificial saliva	Tea tree oil	-.78125	.29091	.064
	Tea tree oil with coconut oil	-1.91850*	.29091	.000*
	Chlorhexidine	-1.79885*	.29091	.000*
	Phosflur	-2.26150*	.29091	.000*

*Post Hoc Tukey's test $p < 0.0$

Table 4 shows unpaired t-test comparing Tea Tree oil and Chlorhexidine. There was a statistically significant difference observed with Chlorhexidine having a higher score than Tea Tree oil (p value = .002*).

Table 4: comparison between tea tree oil and chlorhexidine

Group	N	Mean	Std. Deviation	P value
Tea tree oil	20	1.9673	.50937	.002*
Chlorhexidine	20	2.9849	1.15112	

*Unpaired t-test shows $p < 0.05$

Table 5 shows Unpaired t-test comparing Tea Tree oil and Tea Tree oil with Coconut oil. There was statistically significant difference ($p < 0.05$) between them with Tea Tree oil & Coconut oil having higher frictional resistance score.

Table 5: comparison between tea tree oil and tea tree oil with coconut oil

Group	N	Mean	Std. Deviation	P value
Tea tree oil	20	1.9673	.50937	.002*
Tea tree oil with coconut oil	20	3.1045	1.05333	

*Unpaired t-test shows $p < 0.05$

Table 6 shows Unpaired t-test comparing Tea Tree oil and Phosflur. The mean score of Phosflur showed higher scores than Tea Tree oil. This difference between the groups was Statistically significant ($p < 0.05$).

Table 6: comparison between tea tree oil and Phosflur

Group	N	Mean	Std. Deviation	P value
Tea tree oil	20	1.9673	.50937	.000*
Phosflur	20	3.4476	1.02719	

*Unpaired t-test shows $p < 0.05$

Discussion

The resistance to motion encountered when one body slides over the other is called Friction.[4] Static and Dynamic are the two types of friction.[5] Static friction is the initial resistance that prevents the actual motion. Dynamic friction is the resistance to movement that exists during motion.

Several factors such as arch wire size, shape and material, bracket width and material, ligature design and lubricant play a crucial role in influencing friction.[5] The strength and number of bridges formed between the aspirates of sliding surfaces is reduced by a lubricant. Though natural saliva is the best lubricant, artificial saliva can be used to mimic natural saliva for experimental studies. [5-6]

Oral rinses are used for antimicrobial, antiplaque, anti-inflammatory and remineralization property during treatment. [4&7] There are side effects like teeth staining and their influence on friction in sliding mechanics.[8] Recently the tea tree oil herbal extract mouthwash has been used as orthodontic oral rinse.1,8 Cineole and Terpinen-4ol are the active ingredients of tea tree oil mouthwash and has antibacterial and anti-inflammatory properties.[2] Colgate Phosflur, Chlorhexidine, Tea tree oil and Tea tree with coconut oil are the four mouthwashes used in this study (Figure 5).

The artificial saliva that composed of CMC 500mg, sodium fluoride 20mg, xylitol 3g, potassium phosphate 35mg, sodium chloride 90mg, potassium chloride 120mg in 100ml of aqueous solution was used as control group. The artificial saliva is known to produce least values of frictional resistance at the bracket arch wire interface during sliding mechanics. [9]

Lubricating medium has an important role in friction at the bracket wire interface.[10] Michael Tselepsis et al concluded that the frictional resistance between Stainless steel arch wire against stainless steel bracket in wet condition produces the least values.[5] Fabricio Anderson

et al proved no significant difference between natural saliva and mucin-based saliva.

Chlorhexidine mouthwash consists of chlorhexidine gluconate solution diluted to chlorhexidine gluconate 0.2%, known for its anti-plaque, antimicrobial and anti-inflammatory property. Though chlorhexidine is a gold standard mouthwash their long-term use causes staining of teeth, dryness and burning of oral mucosa. Tahereh Hossein Zadeh Nik et al found chlorhexidine had no effect on the frictional property between bracket and wire.[11] According to Hossein et al mouthwash can change the surface quality and the mechanical properties of arch wire. In a study done by Elham et al chlorhexidine group showed greater surface roughness and frictional resistance.[8] Conversely an investigation done by Noor M Garma et al, the results showed chlorhexidine as a best mouthwash to use with Stainless steel brackets.[12] In this study the chlorhexidine showed frictional resistance value greater than tea tree oil mouthwash group but comparatively less than fluoride containing mouthwash.

Colgate Phosflur is composed of sodium fluoride 0.04%. The pH is 3.5 to 7 and this can damage the oxidized layer on SS and lead to roughness and corrosion of the surface. Though the fluoride mouthwash has been in use during and after treatment for remineralization property and inhibition of white spot lesion, they tend to affect the mechanical property of the wires.[13] Mary P. Walker et al found the mechanical properties were decreased when NiTi arch wire was exposed to fluoride prophylactic agents.[14] Kavitha Nanjundan et al concluded, there may be a long-term effect on the mechanical properties of the brackets when exposed to acidic food products.[15]

Chia-Tze Kao et al in their investigation found that the fluoride containing agents had the property of causing anchorage loss and prolong treatment duration.[16] Allahyar Germy et al found that the fluoride group reduces the tooth movement by decreasing the force applied.[17] Arun Rajendran et al found that the mechanical properties of TMA wire are affected by fluoride rinse when used routinely.[18] According to a SEM study done by Shiva et al, the fluoride gel group showed greater values of static and dynamic friction compared to aqua fresh group. Similar to the previous studies, the results of this study showed the values of the frictional resistance was greater in fluoride containing group when compared to other mouthwashes used. Betal Rahman et al found Cetylpyridinium chloride an alcohol-free mouthwash shall be an alternative for chlorhexidine.[19]

The trending herbal Tea tree oil mouthwash that is composed of Glycerin, Polysorbate 80, Melaleuca alternifolia leaf oil, Aloe Barbadenesis leaf juice, Mentha viridis leaf oil, Hamamelis virginiana extract, ascorbic acid, calcium ascorbate, citric acid is the other mouthwash used in this study. Groppo F C et al in their study found that the tea tree oil was active against all microorganisms including streptococcus mutants.[3] Tea tree oil and garlic can be used instead of chlorhexidine.[3] Sean D.Cox et al proved the potency of the antimicrobial property of essential oil of Melaleuca alternifolia. According to Rashtra Bhushan et al aloe dent mouthwash showed least frictional resistance.[13] Similarly, the values of this study showed no statistically significant difference between tea tree oil and artificial saliva. Further tea tree oil can be used as a safer prophylactic agent as they do not have any side effects or influence over frictional resistance. In accordance with the study done by Jayanti Choudhary et al the Tea tree oil is preferred over chlorhexidine and tea tree oil with coconut oil.[4]

Tea tree oil with coconut oil mouthwash is composed of Glycerin, Polysorbate-80, virgin CoCos Nucifera oil, Mentha piperita stem/leaf oil, Aloe Barbadenesis leaf juice, Hamamelis virginiana extract, Mentha viridis leaf oil, Piper nigrum fruit oil, Melaleuca alternifolia leaf oil, Magnesium chloride, Zinc citrate, Ascorbic acid, citric acid, phytic acid, calcium ascorbate and xylitol. When tea tree oil is compared to tea tree oil with coconut oil, the frictional values of tea tree oil with coconut oil (3.1045±1.05333) is greater than the plain tea tree oil group (1.9673±0.50937). The coconut oil group had no influence on reducing the frictional resistance compared to plain tea tree oil.

As the artificial saliva can be substituted for the natural whole saliva, it's been used as a control group in our study. Tea tree oil and artificial saliva showed no significant difference between them(p=0.64). But the difference between artificial saliva to chlorhexidine, tea tree oil with coconut oil and Colgate Phosflur is statistically significant (p=0.000). Colgate Phosflur showed greater values (mean=3.4476) among other mouthwashes. In this study the values of frictional resistance of Chlorhexidine mouthwash were lesser than the tea tree oil with coconut oil group. The fluoride containing Colgate Phosflur (3.4476±1.02719) was greater than tea tree oil (1.9673), tea tree oil with coconut oil (3.1045) and chlorhexidine (2.9849) mouthwash used in this study. The values of Tea tree oil (1.673±0.50937) mouthwash showed the least score among the four groups compared with artificial saliva. So, tea tree oil can be safely used as a prophylactic agent during orthodontic treatment. The values showed the coconut oil with tea tree oil had no influence in reducing the frictional resistance as the plain tea tree oil mouthwash.

Though the investigation of the current study imitates the actual clinical application and gives us a guideline for selecting the mouthwash that does not have much influence on increasing the frictional resistance during orthodontic care, further in vivo studies are advocated to guide the clinician to choose the best mouthwash during treatment.

Conclusion

1. There is no significant difference in the frictional resistance generated between the orthodontic bracket and arch wire in artificial saliva and Tea tree oil mouthwash.
2. Statistically significant difference in frictional resistance was observed between Artificial saliva and Chlorhexidine, Tea Tree oil with coconut oil and Phosflur mouthwash.
3. Tea tree oil mouthwash showed least values of frictional resistance when compared to Phosflur and Chlorhexidine mouthwash.
4. Phosflur mouthwash showed greater values of frictional resistance among other mouthwashes included in the study.
5. Tea tree oil mouthwash showed frictional resistance values similar to Artificial saliva and hence can be prescribed as prophylactic agent for maintaining oral hygiene during orthodontic treatment.
6. Coconut oil with Tea tree oil increases the frictional resistance compared to plain Tea tree oil. The values of Tea Tree oil with coconut oil ranged between chlorhexidine and Phosflur.

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