JMGCB
ISSN:3032-1085
https://doi.org/10.61796/jmgcb.v1i3.379

Evaluation of different mouthwashes through their effect on their influence on the force loss of orthodontic elastic ligatures

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Received: Feb 27, 2024; Accepted: Feb 27, 2024; Published: Mar 27, 2024;

Abstract: Background: In several orthodontic treatments, elastomeric chains are utilised to produce force, however, this force degrades over time, which may impact tooth mobility. This study aims to investigate how different mouthwashes (Chlorhexidine 0.2%, Sensodyne, and Listerine) may affect the force degradation of two different types of elastic ligatures (Ortho Matrix and 3M Unitek) through the amount of force remaining.

Materials and methods: Two control groups and six experimental groups each included 600 pieces of the elastomeric chains Ortho matrix (OM) and 3M Unitek (3M). Pieces were stretched to a 25mm thickness, placed on pins set into an acrylic block, and kept at 37°C in artificial saliva. For the duration of the study, each of the test groups spent one minute immersed in one of three distinct kinds of mouthwash. Ten continuous thermocyclers with temperatures ranging from 5 to 55 degrees Celsius were performed each day, alternating between cold and hot water baths. While calculating the forces, we considered six different time intervals: the beginning, 24 hours, 1, 2, 4, and 6 weeks. The one-way analysis of variance (ANOVA) test and the t-test were used to compare the mean force of a number of different mouthwashes, elastomeric chains, and times. A value of 0.05 was chosen as the cutoff for statistical significance.

Results: Over time, both types of elastomeric chains significantly lost force at 6 weeks ($p<0.05$). At all times, the 3M Unitek (3M) created more force than the Ortho matrix (OM) elastomeric chain.

Compared to other mouthwashes, chlorhexidine mouthwash had a substantially less impact on force degradation, with discernible very simple change when compared to control groups (Artificial saliva). Conclusion: According to findings, the 3M Unitek offered a higher force level than the other sort of elastomeric chains, and there is a difference that is clinically significant between the two types of elastomeric chains. It is possible that the pH of the mouthwashes, as opposed to other substances, contributes to the gradual loss of power over time. Mouthwashes containing chlorhexidine had the third-smallest influence on the force degradation of elastomeric chains, after Sensodyne and Listerine..

Keywords: Ortho Matrix, 3M Unitek, Chlorhexidine 0.2%, Sensodyne, Listerine, mouthwash.

Introduction

Plaque accumulation is exacerbated by fixed or removable orthodontic equipment, which makes it difficult to keep the teeth clean and encourages buildup [1]. Moreover, orthodontic equipment diminishes the impact of brushing on plaque and salivary flow. During orthodontic attachment bonding, increased amounts of Streptococcus mutans and lactobacilli are identified in the oral cavity [2]. Nowadays, synthetic elastic modules (often referred to as plastic modules) are used in numerous fields of orthodontics [3]. The elastomeric material's smooth surface offers an irritant-free system. Thus, it does not have the same issue with tissue irritation as ligature wires when they protrude [4,5]. On the other hand, oral hygiene issues have not been eradicated entirely since there is a bigger quantity of material around the bracket than there was with the wire ligature [6]. Plaque forms around the device in the absence of adequate dental care, producing gingivitis and decalcification of the enamel [7]. To prevent such issues, the orthodontist has a dual responsibility: to advise the patient on plaque management strategies and to assess the success of the oral hygiene regimen during regular appointments [8]. Since mechanical plaque removal techniques need time, motivation, and manual dexterity, it is difficult to successfully teach, train, and motivate patients to remove plaque by mechanical means alone [9]. This is particularly true for fixed orthodontic equipment, which has been noted as having a significant plaque buildup [10,11].

Mouthwash, often known as a mouth rinse, is an oral hygiene solution. Antiseptic and anti-plaque mouth rinses claim to eliminate the bacterial plaque responsible for dental cavities, gingivitis, and foul breath. Fluoride is used in anti-caries mouthwash to guard against tooth decay [12,13]. However, using mouthwash does not negate the requirement for brushing and flossing. In the absence of mouthwash, it is advisable to gargle with water to eliminate food particles, sugars, and other contaminants from the mouth [10,12]. Mouthwashes may also be used to clear mucus and food particles from the throat's deeper regions. Mouthwashes with alcohol or a strong flavour may produce coughing for this reason. On the pH scale, a significant number of commercial mouthwashes are very acidic [14]. To minimise inflammation, it is recommended to use mouthwash with a neutral pH. In reality, chlorhexidine mouthwash has increased in popularity [15], particularly in the first four to eight weeks of orthodontic treatment, when plaque management may be advised. Listerine is an essential oil/phenolic mouthwash that has shown modest plaque-inhibiting and gingivitis-fighting properties [16]. Several short- and long-term investigations on home usage have shown that it has modest plaque-inhibiting benefits and some

anti-inflammatory effects in lowering gingival inflammation [17]. Sensodyne is a mild mouth rinse. It must be used daily to assist the care of teeth and gums that are sensitive. Fluoride is used to prevent tooth decay and strengthen teeth [18]. It includes an antimicrobial ingredient to combat tartar and safeguard the gums. In mouthwashes and toothpaste, triclosan may also function as an anti-inflammatory agent. It has been proven to diminish the inflammatory response caused by sodium lauryl sulphate and nickel hypersensitivity in the gingiva and skin. In addition, it reduces histamine-induced cutaneous irritation as well as the severity and healing time of aphthous ulceration [18,19].

Material and methods

In this study, two short transparent elastomeric chains with distinct architectures were used. These chains were referred to as Ortho matrix (OM) and 3M Unitek (3M) (USA). Three different types of mouthwash were used namely: Corsodayl: 0.2% Chlorhexidine®(UK) Sensodyne® (gsk, UK).and Listerine® (Pfizer, USA).

A total of 600 pieces were used, with each company receiving an equal amount for its Ortho matrix (OM) and 3M Unitek contributions (3M). There were four groups for each kind of elastomeric chain: a control group in which the elastomeric chain was submerged in artificial saliva, and three test groups, each of which consisted of one participant using a different kind of mouthwash. Each segment of the elastomeric chain had a length of five loops and an additional half loop at either end to protect it from any damage that may occur during handling [20]. The readings from a digital pH metre ("GOnDO" , "PL-700PC" , "Taipei/Taiwan") were used to determine the pH of each mouthwash as well as the artificial saliva, and the results are shown in "Table 1" .

Ten acrylic blocks with twenty stainless-steel pins stretched and held the elastomeric components. The 20 pins were spaced 25mm apart in two parallel rows to match the canine-first molar gap [21]. A digital force gauge measured the residual forces of 600 mountings at six-time points: time 0 under dry circumstances, 1 day and 1,2,4 and 6 weeks ("Weiheng" , "China").

The acrylic block was anchored to a workstation during the force measurement. The tensile force was measured by attaching one end of the elastomeric chain to the force tester and pinning the other end. The force of twenty distinct pieces, 10 of each sort, was measured at two separate moments in time: initially (when the pieces were dry), and then one day later (only kept in artificial saliva). 100 pieces were then tested for the residual force at each time point as mouthwash exposures begin immediately after the 1-day force test. The elastomeric chain samples were maintained in plastic containers with artificial saliva and incubated at 37°C for the test (except for those evaluated for initial force).

Table 1: pH of each chemical solution

Media	pH
Artificial saliva	7.1
Chlorhexidine	7.47
Sensodyne	6.12
Listerine	4.47

After the force measurement on day 1, all samples proceeded through 10 continuous thermocyclers each day, rotating between cold (5°C) and hot (55°C) water baths with dwell and exchange

intervals of 30 seconds [20]. This replicated oral temperature changes. Experimental samples from fake saliva were immersed in mouthwash for one minute every 12 hours.Mouthwashes were replaced every day from day 2 through the end of the study. They went to a mouthwash-specific distilled water bottle after immersion [21]. Incubation at 37°C followed by washing. Mouthwash-free controls got artificial saliva.

Statistical Analysis

SPSS version 26, Microsoft Excel 2013, Using normality tests, we determined whether the study's data was parametric or non-parametric. Statistical tests were thus used. Oneway ANOVA and T-test independent evaluated differences.

Results

In Table 2, the mean and standard deviation (SD) of the force values for two types of short, transparent elastomeric chains immersed in each chemical solution for differing amounts of time are shown. The effects of time were statistically significant ($p<0.05$) at all stages of time and across all groups.

Table 2: The mean value of force degradation of Ortho matrix and 3M Unitek elastomeric chains treated with various chemical solutions.

Duration	Elastic type	Artificial saliva Mean±SD (gm)	Chlorhexidine Mean±SD (gm)	Sensodyne Mean±SD (gm)	Listerine Mean± SD (gm)	p .value
Initial	Ortho matrix	345.64±5.78	350.14±1.77	350.20±1.85	349.86±2.89	< 0.001
	3M Unitek	374.74±3.82	374.78±3.83	374.70±3.803	374.82±3.82	
1 day	Ortho matrix	190.26±3.306	190.26±3.306	192.26±3.306	190.26±3.31	< 0.001
	3M Unitek	212.38±5.938	210.38±5.938	214.38±5.94	213.38±5.94	
1 week	Ortho matrix	152.42±1.918	146.14±3.511	148.66±2.134	148.74±2.239	< 0.001
	3M Unitek	163.78±2.845	154.42±2.741	154.40±2.785	154.16±2.944	
2 weeks	Ortho matrix	142.26±1.575	141.26±1.575	140.64±1.549	139.64±1.549	< 0.001
	3M Unitek	147.62±1.028	146.62±1.028	145.62±1.028	144.62±1.028	
4 weeks	Ortho matrix	131.76±1.492	130.76±1.492	129.76±1.492	127.76±1.492	< 0.001
	3M Unitek	137.52±1.555	136.52±1.555	136.52±1.555	134.52±1.555	
6 weeks	Ortho matrix	122.24±1.779	121.24±1.779	120.24±1.779	119.24±1.779	< 0.001
	3M Unitek	127.18±1.273	126.18±1.273	125.18±1.273	124.18±1.273	

A T-test compared directly between the means of force (in percentage) of the OM and 3M types of elastic ligatures at each time for each specific media, all the reading showed a highly significant difference ("Table 3").

Table (3): Comparison between the mean of remaining force in percentage of the OM and 3M types of elastic ligature.

Media	Duration	Ortho matrix Mean±SD	3M Unitek Mean±SD	Comparison		
				Mean difference	t-test	p. value
Artificial saliva	1 day	190.26±3.306	212.38±5.938	-22.120	-24.054	< 0.001
	1 week	152.42±1.918	163.78±2.845	-11.36	-23.413	< 0.001
	2 week	142.26±1.575	147.62±1.028	-5.36	-20.148	< 0.001
	4 week	131.76±1.492	137.52±1.555	-5.76	-18.898	< 0.001
	6 week	122.24±1.779	127.18±1.273	-4.94	-15.968	< 0.001

Chlorhexidine	1 day	190.26±3.306	210.38±5.938	-20.12	-24.054	< 0.001
	1 week	146.14±3.511	154.42±2.741	-8.28	-13.085	< 0.001
	2 week	141.26±1.575	146.62±1.028	-5.36	-20.148	< 0.001
	4 week	130.76±1.492	136.52±1.555	-5.76	-18.898	< 0.001
	6 week	121.24±1.779	126.18±1.273	-4.94	-15.968	< 0.001
Sensodyne	1 day	192.26±3.306	214.38±5.94	-22.12	-24.054	< 0.001
	1 week	148.66±2.134	154.40±2.785	-5.74	-11.568	< 0.001
	2 week	140.64±1.549	145.62±1.028	-4.98	-18.945	< 0.001
	4 week	129.76±1.492	136.52±1.555	-6.76	-22.179	< 0.001
	6 week	120.24±1.779	125.18±1.273	-4.94	-15.968	< 0.001
Listerine	1 day	190.26±3.31	213.38±5.94	-23.12	-24.054	< 0.001
	1 week	148.74±2.239	154.16±2.944	-5.42	-10.362	< 0.001
	2 week	139.64±1.549	144.62±1.028	-4.98	-18.945	< 0.001
	4 week	127.76±1.492	134.52±1.555	-6.76	-22.179	< 0.001
	6 week	119.24±1.779	124.18±1.273	-4.94	-15.968	< 0.001

Discussion

Many factors can affect the behaviour of rubber elastic, including elastic ligature; among these are stretching, wet conditions, thickness of the elastic, temperature, time, the pH of the environment, and the viscosity of the media [22,23]. In this study, after deforming the elastic to a fixed strain at a constant temperature, the measuring of force as a percent of the force remaining was considered to be more meaningful than the actual force values that have been recorded for a given experimental study. Laboratory models of oral cavity conditions have not correctly predicted such things as the relaxation characteristics of elastic ligature in vivo, besides other factors that affect the force decay, such as environmental differences, mastication, tooth brushing, enzymes, thermal changes, and food interactions. Because force degradation was shown to be greater in wet surroundings than in dry ones in certain investigations, artificial saliva was used as the control group [23,24].

As temperature variations are a significant factor in how orthodontic chains behave, the chains were thermocycler in this work. 300 g was utilized as the beginning force since it is the amount of force typically required for the canine's distal migration [25].

In an effort to reduce the impact of other confounding factors such as pH, damp environments, stretching, temperature, and mastication, this investigation was conducted in vitro. Six-time periods (initial, one day, one week, two weeks, four weeks, and six weeks) were used to test the elastomeric chains in order to track changes that develop over time between adjustment sessions and compare the outcomes of previous research [26].

According to Proffit et al. [27], who thought it was a more usual appointment cycle, the 4 and 6-week time periods were likewise selected as an endpoint. Unlike chlorhexidine mouthwashes, which should not be used for more than two weeks in a row to prevent their negative effects, all evaluated mouthwashes are over-the-counter and have no use restriction [28].

The initial force values ranged more than 300gm, which means that both types of chains delivered force levels above the 300-gm threshold proposed by Lotzof et al. [29] as clinically acceptable for tooth or group movement. The present study revealed that both types of elastic (OM and 3M) showed that time of exposure was a significant factor in this study, since the mean values of the force remaining showed a gradual decrease. After the first day, the most significant decrease in the elastic force occurred; as time progressed, the degradations would become slower for both types (OM and 3M).

In addition to time and stretching parameters, all testing media seem to impact the size of residual force relative to the original force. Water sorption alters elastomeric materials, allowing molecules or polymer chains to glide past one other, increasing the force decay process [30, 31]. In contrast to Bales et al. [32] who reported the force relaxation relationship for most of the items evaluated was dramatically altered by a moist environment but had a comparably little effect on most synthetic products.

Actually, the present study revealed the force decreased in two ways: either in a steady way after a large part of the initial force dropped quickly in the first few hours, or in a slow way over time. This was seen in the control media (artificial saliva), Sensodyne, and Listerine mouthwashes. This was in accordance with the finding of several studies of elastomeric products Singh et al. [33] Leao Filho et al. [34]

The other result of force decay demonstrated also a sudden drop as in Chlorhexidine mouthwashes. This pattern was previously mentioned by Evangelista et al. [35] and Santos et al. [36].

This can be explained by the fact that the elastomeric material might develop more than one module of elasticity [37], During stress relaxation and quick force reduction, the elastomeric may absorb the test solution and stiffen, so after absorption of the test solution and intruding of water molecules into the elastic material, disruption of secondary or covalent bonds of strained polymers occurred and led to plasticization following chemical degradation of the polymer backbone with longer exposure times [38].

The amount of residual force was higher in Sensodyne mouthwash, which had a weaker acidic medium (pH level = 6.0), yet the weaker acidic medium limited the hydrolytic capacity of the organic solvent for the material constituents. Whereas the lowest amount of residual force was in Listerine mouthwash, which had a stronger acidic medium (pH level of 4.47). These findings came in agreement with Shaddud et al. [38] and Losito et al. [39] who saw that the acidic medium is more likely to cause breakdown of molecules of elastomers and increase its creep, but disagreed with Javanmardi & Salehi et al. [40], who discovered that the basic solution had a force decay rate that was much higher than the acidic solution over the course of four weeks.

A comparison between the two types of elastic ligature (OM and 3M) showed a highly significant difference between them. In fact, 3M elastic ligature showed greater force decay than OM type in all media. This is due to the fact that there are no internationally recognised standards for the mechanical qualities of orthodontic elastic or elastomeric materials [41].

Most orthodontic elastomers have a similar production method, although they vary in cutting or injection moulding the basic material, additional effects, and morphologic or dimensional aspects [42]. Actually, the 3M type exhibited a greater initial force than the OM type, which made the force decay greater at the end of the experiment.

This agrees with Evangelista et al. [35] and AL-Faham [43], and, but disagrees with De Genova et al. [44], who found that the greater the initial load, the less the force decay. However, although these two types showed a significant difference in the amount of force remaining, they still displayed, in general, the same behaviour. Therefore, differences in the initial and remaining forces were noted among different companies even with the same brand design and investigation conditions. The material's glass transition temperature (Tg) is connected to its molecular structure, stiffness, and force delivery [45,46]. It represented the temperature range at which the material changes from glassy to rubbery. The greater the Tg, the stiffer the polymer, and the change in Tg

following extended exposure to solutions shows intermolecular link breakage [35].

Conclusion

Force degradation peaked in the first 24 hours for all groups and subsequently increased throughout testing. Both kinds of elastomeric chains maintained the force level for 6 weeks, which is clinically sufficient for orthodontic tooth movement. The 3M Unitek chain produced a greater force level at all times than the Ortho Matrix. Chlorhexidine mouthwash least impact on the force degradation of elastomeric chains after Sensodyne and Listerine

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