The Effect of Sodium Fluoride and Listerine Mouthwashes on the Force Decay of Orthodontic Elastomeric Chains

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ABSTRACT
Elastomeric chains are commonly used in orthodontic treatments. If their force decreases, the need for changing them will increase. This study aims to evaluate the effects of three different mouthwashes on the force loss of two different orthodontic chain brands. Forty five chains from each American Orthodontics (AO) and Dentaurum (DR) brands were divided into three subgroups. The chains of all6 groups were stretched 25 mm and immersed in related solutions (sodium fluoride 0.05% (SF), Listerine (LS) and artificial saliva (control group). The specimens were incubated at 37˚c between the test intervals. Elastics force was tested before the test and after one hour, twenty four hours, one week, two weeks and three weeks by Electromechanical Universal Testing Machine. To compare the results, ANOVA, Tukey and T-test were (level of significance= 0.05) performed. The mean force in control group was higher than those of two other solutions (PV<0.001) but the differences between sodium fluoride and Listerine groups were not statistically significant (P=0.527). Before (P<0.001) and one hour (P<0.001) after the test, the mean chain force in AO was higher than that of DR brand. Twenty four hours after the test, there was no significant difference between the two brands (P=0.519).However, one week (P<0.001), two weeks (P<0.001) and three weeks (P=0.035) after the test, the mean forces in DR brand were higher. These of Sodium fluoride and Listerine mouthwashes can speed up force degradation in chains. The force loss in DR brand is less and slower than that of AO brand.

Key words: Elastomeric Chains, Force Decay, Mouthwash


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INTRODUCTION
Application of the forces lightly and constantly to ensure the maximum tooth movement with minimum resorption is one of the primary goals in orthodontics [1, 2]. Space closure with orthodontic dental movement is clinically important [3]. Variable systems, including Ni-Ti Coil springs and elastomeric products are used for space closure [4]. Among these, elastomers are more common because of their lower cost and simplicity [5]. These materials are amorphous polymers that have been used by orthodontists for space closure and rotation corrections since 1960[6-8]. Elastomeric chains are appropriate alternatives for latex materials in orthodontics whose protein content is allergen and causes allergic reactions in patients [9]. Patients are comfortable with Elastomeric chains [10]. Theses elastics are not appropriate for microorganisms and exist in variable colors [10].Despite the mentioned favorable features, these chains aren't ideal since they undergo force decay [11]. Chain forces are dependent on some factors, including the materials used in factory, added colors, shape of chains ( open or closed), stretching chains before using them, and sterilization and preservation techniques[3]. Deformation, force
decay and relaxation behaviors of elastomers are also dependent on environmental factors like
teeth movement, temperature changes, environmental PH, mouth washes, salivary
enzymes and mastication forces [12].

A decrease of 50-70% of primary force has been reported after 24 hours; whereas the most has been
found in the first hour, followed by a continuous decrease happening in weeks 3 to 4
[13, 14]. A part of elastomer force is decreased
due to sliding resistance between bracket and
wire, which includes friction between wire and bracket, contact between wire and sides of
bracket slot(binding) and permanent deformation
in bracket- wire contact(notching)[15, 16]. The
rapid decrease in forces of viscoelastic chains
causes insufficient tooth movement that result in
increased appointments for activating the
appliance [17]. Appropriate plaque control for
orthodontic patients is difficult, especially when
ligature, wire and band are placed on the teeth
[18]. Bacterial plaque is more likely to be created
around brackets and bands [19, 20]. Dentists
recommend using mouthwashes during
orthodontic treatment to promote oral hygiene
and decrease caries lesions [21]. It is shown that
using chemical agents along with tooth brushing
and flossing is better than mechanical control
alone, in the way that both plaque and gingival
inflammation decrease [7]. Recent systematic
reviews have shown that chlorhexidine and
Listerine have the most anti-plaque and anti-
gingival inflammatory effect. Chlorhexidine causes
long term disadvantages like tooth color change
and taste alteration, but Listerine does not show
these disadvantages, so it’s the first choice for
daily and long term use for orthodontic patients
[22]. Applying sodium fluoride as an ionized
fluoride on the tooth surface causes calcium
fluoride sedimentation on the enamel surface. In
the natural conditions, this layer can stay on the
tooth for weeks or even months [23].

In 1992, Von Fraunhofer et al., evaluated the effect
of artificial saliva and local fluoride on the
degradation characteristics of chains and
concluded that using fluoride increased the need
for stretching the same amount of forces [24]. In
2008, Ramezanizadeh et al., reported that
application of sodium fluoride mouthwash did not
have any statistically significant effect on the force
degradation of the studied chains [25]. In the
study of Bratu DC in 2013, the efficacy of artificial
saliva and fluoride was evaluated, and it was
concluded that both of them increased the force
decay in chains [26]. In 2014, Kumar et al.,
evaluated the effect of common mouthwashes and
beverages on the force transmission
characteristics of the chains. In this study,
Listerine mouthwash increased the force decay
of the chains [27]. Evaluating the probability of force transmission
disability in systems is essential because in such
situations the dentist cannot estimate the actual
force transferred to the dentition [13]. Considering the probable effect of mouthwashes
on reducing elastomeric chain forces, this study
was aimed to evaluate and compare the effect of
Listerine and sodium fluoride mouthwashes on
two commercial chain brands.

**MATERIAL AND METHODS**

Ninety gray elastomeric chains with short inter
loop space from two different brands -American
orthodontics (Sheboygan, Wisconsin, USA) and
Dentaurum (Ispringen, Germany) were studied.
Pieces with a length of five rings were prepared.
To prevent probable damages to the chains, the
loops adjacent to the terminal rings were cut using
a sharp ligature cutter. Forty five chains from each
brand were randomly divided into three
subgroups of artificial saliva (Hypozalix, biocodex,
France) as control group, sodium fluoride 0.05%
mouthwash(Epimax, Emad pharmaceutical co,
Iran) and Listerine mouthwash(Zero, Johnson&
Johnson, Italy). Finally 6 groups of 15 elastics
were obtained:

- **Group A**: (control group): American orthodontics
  brand in artificial saliva.
- **Group B**: American orthodontics brand in sodium
  fluoride mouthwash.
- **Group C**: American orthodontics brand in
  Listerine mouthwash.
- **Group D (control group)**: Dentaurum brand in
  artificial saliva.
- **Group E**: Dentaurum brand in sodium fluoride
  mouthwash.
- **Group F**: Dentaurum brand in Listerine
  mouthwash.

To simulate an oral condition, all of the specimens
were incubated (Behdad, Tehran, Iran) at 37 °C in
artificial saliva. Artificial saliva ingredients were
water, Mgcl2, Nacl and cellulose materials as
viscous agent, with PH=7.2 and 110 cps viscosity.
For the two control groups, the chains were just
placed in artificial saliva and incubated at
37°C. For the other four groups, the chains were brought out of the artificial saliva every day and for one minute immersed in the mouthwash that was specified for each group. After bringing the chains out of the mouthwash, to simulate the real method of mouthwash use, the chains were immersed in the 50% artificial saliva and 50% mouthwash for 30 minutes (sodium fluoride or Listerine depending on the group) and then kept again in artificial saliva and incubated at 37°C. (Clinical mouthwash use method: oral rinsing with one measure of mouthwash, avoiding eating or drinking for half an hour [28]).

A custom device containing 2 rows of sixteen stainless steel fixtures with 1.2 mm diameter was created. The fixtures were mounted in self-cure acrylic resin (Acropas, Marlik Co., Iran) and set 25 mm from each other to simulate the distance between the hook of the first molar and distal wing of canine bracket[29, 30].

In this distance, the chain force is about 100, 300 grams, which is suitable for canine retraction [13]. The chains were stretched between two fixtures. Elastic force was tested before the test and after one hour, 24 hours, 1 week, 2 weeks and 3 weeks. The force was measured by Electromechanical Universal Testing Machine (k_21046, Lohringen, Switzerland) in the mentioned intervals (figure 1-b).

![Figure 1: (a) elastomeric chains mounted on fixtures (b) Electromechanical Universal Testing Machine (k_21046, Lohringen, Switzerland)](image)

For testing, the elastics were demounted from the fixtures and allowed to be relaxed. To transfer the elastics from the fixtures to the testing machine, a modified separating plier was used. The head of the modified separating plier opened up to 25 mm to stretch all the elastics in the same way (figure 2).

![Figure 2: modified separating plier doesn't open more than 25mm](image)

Elastics were attached to the steel hooks made of 1.2 mm stainless steel wire. The distance of hooks was adjustable. The machine was set in the way that initially the distance between the hooks was 20 mm and as the elastics clamped, this distance increased to 25 mm with 0.5 mm in second speed. The tensile force was shown on the monitor in Newton. Because of the changes in the forces, especially in the first seconds, when the elastics stretched to 25 mm, the force was measured with 10 seconds delay. In each group the percentage of force decay was calculated according to the initial force. The collected data were analyzed using SPSS software (SPSS Inc., Chicago, IL, USA). The mean and standard deviation were calculated for the groups. To evaluate the normality of data, Kolmogorov –Smirnov test was used and the analysis of variance (ANOVA), Tukey’ test and T-test were used to compare the force decay among the studied groups. Differences were considered statistically significant when P<0.05.

RESULTS

In this experimental prospective study, the effect of three different solutions (artificial saliva, Listerine and sodium fluoride mouthwashes) on the force decrease of two different chain brands were evaluated at six time intervals. The three way ANOVA analysis showed that the effect of chain brand on elastic force was statistically significant and the mean force of American
orthodontic brand was totally higher than that of Dentaurum brand (P=0.001). Generally, as the time passed the elastic chain force decreased, which was statistically significant (P<0.001) (table 1). The difference between different solutions was found to be statistically significant (P<0.001). Chain brand and solution did not show any interaction (P=0.956). Time and group showed no interaction as well (PV=0.133). Interaction of chain brand, time and solution were not shown to be statistically significant (PV= 0.995). But the interaction between chain and time was significant (P= 0.001), so the two way ANOVA analysis was performed.

The findings of Tukey test showed that the mean force difference between sodium fluoride groups and Listerine groups was not statistically significant (P=0.527) but in control groups, it was higher than those of sodium fluoride or Listerine mouthwash groups (P<0.001) (figure 3-a).

The results of two-way ANOVA analysis showed that in American orthodontics brand groups, there was a significant difference between different solutions (P=0.001). The post-hoc Tukey test showed that the difference between sodium fluoride groups and Listerine groups was not statistically significant (P=0.827), but in control group, it was higher than SF (P=0.011) or Listerine groups (P=0.002). Also, in Dentaurum brand groups, there was a significant difference between different solutions (P=0.002). The post-hoc Tukey test showed that the difference between sodium fluoride groups and Listerine groups was not statistically significant (P=0.625), but in control group, it was higher than SF (P=0.031) or Listerine groups (P=0.002).

The results of t-test showed that before (P<0.001) and one hour (P<0.001) after the test, the mean chain force in AO brand was higher than that of DR brand. Twenty four hours after the test, there was no statistically significant difference between the two brands (P=0.519). However, 1 week (P<0.001), 2 weeks (P<0.001) and 3 weeks (P=0.035) after the test, the mean forces in Dentaurum brand were higher.

Table 1: Mean forces of AO and DR chain brands in different solutions at different times

<table>
<thead>
<tr>
<th>Solution</th>
<th>Chain brand</th>
<th>Before test</th>
<th>One hour</th>
<th>24 hours</th>
<th>1 week</th>
<th>2 weeks</th>
<th>3 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>AO</td>
<td>312±6.53</td>
<td>290±8.25</td>
<td>247±10.17</td>
<td>205±9.10</td>
<td>186±9.43</td>
<td>166±10.25</td>
</tr>
<tr>
<td>Listerine</td>
<td>AO</td>
<td>313±5.20</td>
<td>280±6.19</td>
<td>244±9.89</td>
<td>201±8.17</td>
<td>176±7.55</td>
<td>156±11.93</td>
</tr>
<tr>
<td></td>
<td>DR</td>
<td>286±5.70</td>
<td>274±7.69</td>
<td>244±7.56</td>
<td>206±8.77</td>
<td>191±11.99</td>
<td>161±12.01</td>
</tr>
<tr>
<td>Sodium fluoride</td>
<td>AO</td>
<td>312±5.715</td>
<td>289±5.15</td>
<td>246±8.85</td>
<td>202±8.62</td>
<td>178±8.16</td>
<td>156±10.68</td>
</tr>
<tr>
<td></td>
<td>DR</td>
<td>285±6.66</td>
<td>273±7.33</td>
<td>247±8.82</td>
<td>209±6.88</td>
<td>191±12.96</td>
<td>164±11.54</td>
</tr>
</tbody>
</table>

Figure 3: (a) Comparison of force (g) changes for study solutions (b) Force (g) changes of chain brands over 3 weeks in different solutions
Table 2. Percentage of the force decay of AO and DR brands in study solutions at different times in proportion to initial time

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Chain brand</th>
<th>One hour</th>
<th>2 hours</th>
<th>1 week</th>
<th>2 weeks</th>
<th>3 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>AO</td>
<td>93.1%</td>
<td>79.3%</td>
<td>65.8%</td>
<td>59.5%</td>
<td>53.1%</td>
</tr>
<tr>
<td></td>
<td>DR</td>
<td>96.8%</td>
<td>87.7%</td>
<td>75%</td>
<td>69.5%</td>
<td>59.3%</td>
</tr>
<tr>
<td>Listerine</td>
<td>AO</td>
<td>92.1%</td>
<td>77.8%</td>
<td>64.2%</td>
<td>56.3%</td>
<td>49.9%</td>
</tr>
<tr>
<td></td>
<td>DR</td>
<td>95.7%</td>
<td>85.5%</td>
<td>72.1%</td>
<td>66.7%</td>
<td>56.3%</td>
</tr>
<tr>
<td>Sodium fluoride</td>
<td>AO</td>
<td>92.9%</td>
<td>79.1%</td>
<td>64.9%</td>
<td>57.2%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>DR</td>
<td>95.7%</td>
<td>86.6%</td>
<td>73.3%</td>
<td>66.9%</td>
<td>57.5%</td>
</tr>
</tbody>
</table>

**DISCUSSION**

In the present study, the effects of two different mouthwashes on the force decay of two different chain brands were evaluated.

An ideal elastomer material turns back to its exact major shape when it is stretched. This rarely happens in the reality because when some of the polymeric chains are stretched, they slide irreversible and lay out in a new way [31, 32]. The applied force makes the molecules of polymer uncoiled; at first, the activated chain is stretched but as the time passes, the molecules slip on each other, which results in a new layout and permanent deformation [33]. Slippage of the molecules as a result of the force continuity reduces the force transfer to the teeth [33]. Based on a study, chain forces reduced 42-63% (dependent on the chain brands) after 21 days in dry condition. When the elastomers were immersed in the water bath, the reduction was faster. The maximum force decay was reported in the first 3 hours [34].

In another study, to simulate oral condition, the elastomers were placed in the water bath with heat circulation. The force reduction after 30 minutes was 23-37% and after 21 days was 39-61%. Also, with preservation of the study conditions, tooth movement was simulated with 0.5 mm reduction in stretch distance of chains weekly. In comparison with heat circulation condition, the force loss was controlled better [17]. Force reduction in elastomeric chains evaluated in vivo was faster than those evaluated in vitro [17]. It is claimed that saliva and water desorption in oral environment causes permanent deformity in elastic chains [30].

The solutions used in this study were Listerine, sodium fluoride and artificial saliva. Artificial saliva was considered for control group to simulate oral condition. It is reported that the force loss in dry environment is more than wet environment [35, 36].

In this study, the difference between mouthwashes and control group was reported to be statistically significant, and as the time passed in both chain brands, the diagrams diverged (figure3- a).

The force decay in Listerine groups was higher than those of control groups.

Listerine is a combination of 4 essential oils as its active agents (including: thymol 0.064%, menthol 0.042%, eucalyptol 0.092% and methyl salicylate 0.060%) in water- ethanol dissolvent [37].

In the study conducted by Pithon et al. [10], the effects of the number of alcoholic beverages on force degradation of elastomeric chain were evaluated and at the end of the study, no significant differences were found between alcoholic beverages and distilled water group. But, Effect of containing alcohol mouthwashes on structure and molecular changes in elastomeric chains and the following force degradation is explained [38, 39]. In the study carried out by Larrabee et al., the chains exposed to alcohol containing mouthwashes showed higher amount of force loss in comparison with water. So, to eliminate probable effect of alcohol on chain’s force, alcohol free Listerine mouthwash used in this study. But still the amount of force decay was higher than control group [39].

Sodium fluoride mouthwash caused greater force loss than control groups did, which was in agreement with the results of Omidkhoda et al.’s study [40] in which sodium fluoride 0.05 caused greater force loss in comparison with control group. However, in the study of Ramezanzadeh et al., no significant differences were observed [25].

The diagram slope of AO brand was greater than DR brand, showing that the decrease in chain force in the AO brand was higher and more rapid. At the beginning, the mean force in AO brand was higher but at the end of the study, it was lower than that of Dentaurm brand (figure3- b).
The range of force decay. That was calculated in proportion to the initial force, in AO brand in all of the time intervals was higher than that of the DR brand (Table 2). In the study of Ramezan zadeh et al. [25], after 3 weeks, the force decay in AO brand was more than that of Dentaurum brand.

Totally, After 24 hours, the force loss was 12-22% of the initial force and at the end of the study; it was 41-50% of the initial force. This range of force loss is close to other studies [40, 41] although, it was lesser than some of the studies [13, 14]. It is claimed that the elastomeric chains properties may be different. So, lack of strict quality control in elastics production may cause different results from same studies [42].

CONCLUSION

The use of sodium fluoride and Listerine mouthwashes can intensify the force loss in the elastomeric chains. However, the force loss effect of these two mouthwashes seems to be the same. The force loss in Dentaurum brand is less and slower than that of American orthodontics brand.

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REFERENCES

15. Kuyp RP, Whitley JQ. Influence of archwire and bracket dimensions on sliding mechanics: derivations and determinations of the critical contact


