A Comparison of Force Decay between Coil Spring, Elastomeric Chain and Tie-backs in Various Alcohol Concentrations found in Mouth Rinse: An In-vitro Study

Asma Fatima¹*, Prasad Konda¹, Asiya Fatima², Hidayathulla Shaikh³, Butool Zohra¹ and Baba Fareeduddin¹

¹Department of Orthodontics and Dentofacial Orthopaedics, Al-Badar Rural Dental College and Hospital, Gulbarga, Karnataka, India.
²Department of Orthodontics and Dentofacial Orthopaedics, Maharishi Markandeshwar College of Dental Sciences & Research, Mullana, Haryana, India.
³Department of Public Health Dentistry, Maharishi Markandeshwar College of Dental Sciences & Research, Mullana, Haryana, India.

Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i42A32396
(1) Dr. Ana Cláudia Coelho, University of Trás-os-Montes and Alto Douro, Portugal.
(2) Mehmet Dalkiz, Belgium.
Complete Peer review History: https://www.sdiarticle4.com/review-history/73204

Received 20 June 2021
Accepted 24 August 2021
Published 27 August 2021

ABSTRACT

Background: The ability to close space efficiently in Orthodontics is of major clinical importance. Elastomeric power chain, coil spring, and tiebacks are commonly used in Orthodontics to achieve tooth movement during the closure of spaces. Many mouth rinses which are used by the patients to achieve good oral hygiene affect the properties of the material used during treatment resulting in force decay if they contain alcohol.

Aim: To know the effect of mouth rinses containing different alcohol Concentrations on the force decay of retraction materials.

Materials and Methods: A study was carried out to test the effect of alcohol exposure found in mouth rinses on orthodontic NiTi closing coils, elastomeric chains, and tie-back. A total of 135 specimens were divided into one control group and two test groups submerged in artificial saliva at

*Corresponding author: E-mail: drasmafatima@yahoo.com;
2. INTRODUCTION

The use of an orthodontic appliance leads to a greater accumulation of bacterial plaque in the oral cavity. Poor oral hygiene is one of the reasons for unsuccessful orthodontic treatment [1]. The various methods used to maintain oral hygiene are mechanical and chemical. Among mechanical methods the use of toothbrushes and dental floss are present. Mechanical methods of plaque removal require time, motivation, and manual skill [2]. In individuals who cannot or find it difficult to perform good oral hygiene, chemical plaque control measures are implemented like a mouth rinse. The various orthodontic appliance used to bring tooth movement are brackets, springs, bands, wires, and elastics [1]. Light continuous forces are advisable during orthodontic treatment to achieve optimal tooth orthodontic movement. The most commonly used retraction products for space closure during orthodontic treatment includes elastomeric chain and modules, and NiTi closing coils [3]. The chemical plaque control measures which are used to achieve proper oral hygiene also have some effect on the force degradation of this orthodontic appliance [1]. Therefore, the study was carried out to know the effects of different alcohol concentrations found in mouth rinses on the force degradation of NiTi closing coils, elastomeric chains, and tie backs, and to compare the amount of force decay of NiTi closing coils, elastomeric chains, and tie-back on day 0, 7th, 14th, 21st and 28th days.

2. MATERIALS AND METHODS

A study was done in the Department of Orthodontics and Dentofacial Orthopaedics, to know the effect of 3 different concentrations of alcohol found in mouth rinses (Listerine and Povidone-iodine) on the NiTi closing coils, elastomeric chains, tie-backs, and Nine jigs were prepared and divided into three groups (1control and 2 test groups). Each group was further subdivided into 3 subgroups (a- NiTi, b- elastomeric chains, c- tie backs). The Control group was for artificial saliva Group I (Fig:1) and the test groups were for Listerine Group II (Fig:2) and Povidone-iodine Group III (Fig:3).

Each specimen was made of a rectangular fiber platform (20 cm x 8 cm x 1 cm), with 2 rows of stainless steel pins. Each row comprises 15 stainless pins. Nine jigs each with a series of pins set at 30 mm apart, were used to stretch and hold the elastomeric chains (eight links), NiTi closing coils (9 mm length), and active tie backs, when stretched and the force was measured using a digital force gauge (Fig:4). The distance between the two rows of pins was 30 mm because it represents the mean length, from the mid-position between the maxillary lateral incisor and canine (the position of soldered hook on the wire in preadjusted system) to the mesial hook on the maxillary first molar band. [3] The force levels of NiTi closing coils, elastomeric chains and tie back were tested in artificial saliva at 37°C (simulating the oral temperature) initially at 0-day, 7th day, 14th day, 21st, and 28th day respectively. Likewise, the experimental groups of NiTi closing coils, elastomeric chains, and tie backs were exposed to three different mouth washes which are commonly prescribed by dental practitioners (Listerine and povidone-iodine), twice daily for one minute at 8 hours’ interval in the presence of artificial saliva. Control and test groups were then placed in an incubator at 37°C to reproduce the oral temperature. Experimental samples were kept in a deionized water bath for 10 seconds to rinse off the alcohol after exposure to mouth wash. Control and test groups force measurements were made at the following intervals initial 0, 7, 14, 21, and 28 days respectively. A single blinded examinee obtained force measurements using digital force gauge with the help of a second examiner. Measurements were made by leaving one end of
the elastomeric chain, coil spring, and tie backs secured on the pin and the other end fixed to the force tester which was stretched till the pin on the opposite row (Fig:5).

2.1 Statistical Analysis

Descriptive statistical analysis including mean and standard deviation was calculated for the groups evaluated. The difference among groups was analyzed using ANOVA followed by Tukey’s test. The comparison between the tensile strength of the NiTi closing coils, elastomeric chains, and Tieback were made and the p-value for tensile strength as measured by the (Digital force gauge) was derived by ANOVA test, multiple comparisons, and Tukey’s correction. The results of the analysis indicated that force degradation of the mean tensile strength for the three different products (NiTi closing coils, elastomeric chain, and tie-back) used when immersed in two different mouthwashes were found to differ at the same time intervals.

![Fig. 1. Jigs immersed in Artificial saliva](image1)

![Fig. 2. Jigs immersed in Listerine mouth wash](image2)

![Fig. 3. Jigs immersed in Povidine-iodine rinse](image3)
Fig. 4. Digital force gauge

Fig. 5. force measurement

Table 1. Mean and standard deviation (sd) of force decay and percentage decay compared to day one

| Day  | Group I | Group II | Group III |
|------|---------|----------|-----------|
|      | la      | lb       | lc        | lla      | ll b     | ll c     | III a    | III b    | III c    |
| 1<sup>st</sup> | Mean  | 547.9    | 310.7    | 339.5    | 547.6    | 311.5    | 340.1    | 547.2    | 311     | 340     |
|      | SD     | 2.5      | 0.9      | 4.0      | 2.9      | 3.1      | 3.9      | 2.8      | 2.9     | 3.8     |
|      | % Decay| --       | --       | --       | --       | --       | --       | --       | --      | --      |
| 7<sup>th</sup> | Mean  | 391.6    | 161.8    | 172.3    | 391.6    | 131.8    | 172.4    | 391.4    | 137.2   | 168.9   |
|      | SD     | 5.0      | 3.8      | 4.8      | 5.0      | 4.3      | 4.3      | 6.3      | 4.0     | 7.3     |
|      | % Decay| 28.5     | 47.9     | 49.2     | 27.9     | 57.9     | 49.3     | 29.0     | 55.9    | 59.3    |
| 14<sup>th</sup> | Mean  | 353.9    | 130.9    | 154.9    | 353.7    | 116.5    | 139.4    | 353.2    | 123.1   | 152.9   |
|      | SD     | 5.7      | 3.5      | 2.4      | 5.1      | 3.1      | 1.8      | 6.3      | 4.7     | 2.2     |
|      | % Decay| 35.4     | 55.3     | 54.3     | 35.1     | 62.8     | 59.0     | 35.5     | 60.2    | 54.9    |
| 21<sup>st</sup> | Mean  | 330.1    | 111.6    | 149.7    | 327.8    | 101      | 130.9    | 327.5    | 107.3   | 139.9   |
|      | SD     | 6.5      | 3.6      | 2.2      | 5.5      | 3.0      | 2.8      | 4.8      | 4.8     | 1.0     |
|      | % Decay| 39.8     | 64.1     | 55.8     | 39.7     | 67.7     | 61.5     | 40.1     | 65.5    | 58.8    |
| 28<sup>th</sup> | Mean  | 307.5    | 89.6     | 140.3    | 307.5    | 72.9     | 129.3    | 307.6    | 85.5    | 136.5   |
|      | SD     | 4.8      | 6.3      | 1.4      | 4.0      | 4.9      | 0.9      | 4.8      | 3.7     | 3.5     |
|      | % Decay| 43.9     | 71.2     | 58.6     | 43.4     | 76.7     | 61.9     | 43.8     | 72.6    | 59.8    |

Table 2. Results of the two way anova of: niti coil spring, elastomeric chain and tie-back force decay for time, groups and the interaction between variables

| Variable    | Sum of square | Degree of freedom | Mean sum of square | F value |
|-------------|---------------|------------------|-------------------|---------|
| Groups      | 470971.3      | 8                | 58871.4           | 680.6   |
| Day         | 295505.8      | 4                | 73876.5           | 854.1   |
| Interaction | 2767.9        | 32               | 86.5              |         |
For decades, many materials are used for closing spaces between teeth like anterior retraction after premolar extraction. These include latex elastic, coil springs, elastic modules, headgear, and magnets. Light and consistent forces are advisable for tooth movement to be optimum during orthodontic treatment. Loss of force of different materials used to move teeth in extraction space has been documented. [4] Therefore the study was done to know whether different mouthwashes that are routinely prescribed with alcohol content like Listerine and Povidone-iodine have an effect on the force degradation of various orthodontic retraction materials which include NiTi closing coils, elastomeric chains, and tie-back. Unfortunately, the forces delivered by these products vary and reduces over time. There are
controversies regarding the optimal force magnitude required for space closure.

The force required to move a tooth is calculated based on the root surface area of the tooth. If during treatment, forces reduce below the optimal level then tooth movement ceases. [5] Previous studies were done by Larrabee et al. [6] and Pithon et al. [1] concluded that mouth rinses with different compositions can effect elastomeric chains force decay. Therefore, the purpose of the present study was to evaluate the effect of various mouthwashes containing alcohol on the force degradation of various materials used for retraction. We observed in the present study, significant loading force degradation from the initial day to day 28th for NiTi closing coils and elastomeric chain in different solvents. Tie-back did not showed significant force degradation from day 21st to day 28th in different solvents. Similar results were seen in other studies done by Josellet al. [6], Andreasen et al. [7], and Hershey et al. [8] Between days 1- 7, 7 – 14, 14 – 21, and21-28 days the force degradation of 3 products (a, b and c) kept immersed in different solvents showed gradual reduction but more force decay was observed from initial day to day 7. These results were in accordance with the previous studies done by Josell et al. [6], Genova et al. [9], Andreasen et al. [7], Singh et al. [10], Kuster et al. [11], and Baty et al. [12] When comparing the tensile strength of NiTi closing coils, elastomeric chains, and Tie-back in artificial Saliva, force decay was observed after the solvent exposure at each follow-up compared to the baseline tensile strength (Initial). The intra product comparison showed significant reduction in tensile strength after the initial day to day 7th for all three products. The inter-product comparison showed baseline and follow-up tensile strength differ significantly between products: NiTi closing coils and elastomeric chain, NiTi closing coil and tie-back, elastomeric chain, and tie-back at each interval. NiTi closing coils showed significantly higher tensile strength when compared to elastomeric chains and tie-back and tie-back when compared to the elastomeric chain. A study done by Nattrass et al. [3] showed significant effect on the force degradation of NiTi closing coils is due to moisture and not by different solutions or the food. The comparison of NiTi closing coils, elastomeric chains, and Tie-back in Listerine and Povidone-iodine mouth wash showed the tensile strength reduced after the solvent exposure each follow-up compared to the baseline tensile strength (Initial). The intra product comparison showed that the tensile strength significantly reduced after the initial day to day 7 for all three products. The inter-product comparison showed that initial and follow-up tensile strength differs significantly between products at each interval. The tensile strength was significantly reduced in the elastomeric chain compared to NiTi closing coils, and tie-back and in tie-back when compared to NiTi closing coils. From the above data, NiTi closing coils are best amongst the three. The studies were done by Nattrass et al [3] and Oshagh et al [13] showed similar results. Study by Oshagh et al. [13] showed the residual force of tie-back was excess than an elastomeric chain at 4th week and tie backs can apply a more constant force than an elastomeric chain.

Comparison of the percentage change in tensile strength compared to initial tensile strength across various products with all solvents.

3.1 NiTi Closing Coils

While evaluating the force decay in percentage for NiTi closing coils average tensile strength did not differ between several solvents at every 8 intervals. This result was in accordance to the previous study done by Nattrass et al [3], which showed the percentage of tensile strength of NiTi closing coils at 28th day was 43%. But in previous studies done by Cox et al. [14], Angolkar et al. [5] showed the percentage of tensile strength of NiTi closing coils at 28th day was 12.12% and 20% respectively.

3.2 Short Elastomeric Chain

While evaluating the percentage of force decay for short type of elastomeric modules, the average tensile strength differs significantly between several solvents at every interval except for day 7th the force decay for elastomeric chains was similar for Listerine and Povidone-iodine. Significant force degradation was observed in short elastomeric chains exposed to Listerine than to Povidone-iodine on day 14th, 21st, 28th. This finding was similar to the previous study done by Larrabee et al. [6] that demonstrated that a highly significant amount of force decay was caused by alcohol. The percentage decay in tensile strength for the short elastomeric chain at 28th day was 71.2% in artificial saliva, 72.6% in Povidone-iodine, and 76.7% in Listerine. In other studies, done by Oshagh et al. [13] and Hershey et al. [8] showed residual force percentage at
28th day in deionized water was 10.23%, 40% respectively.

3.3 Tie Back

While evaluating the percentage of force decay for Tie-back, the average tensile strength did not differ significantly between several solvents on the 7th day. On day 14th, 21st, and 28th the force decay between Listerine and other solvents differs significantly. The force reduction for Tie-back did not differ significantly between artificial saliva and Povidone-iodine at every interval. The percentage decay in tensile strength for tie-back at 28th day was 58.6% in artificial saliva, 59.8% in Povidone-iodine, and 61.9% in Listerine. A study done by Oshagh et al [13] showed residual force remaining at 28th day was 39.22% in deionized water.

This study illustrates that solvents have a statistically significant effect on the force decay of elastomeric chain and Tie-back in vitro, and no statistically significant effect of solvents was found on the force decay of NiTi closing coils. Its clinical implication is still inconclusive. After 28 days the control group had forces ranging from 307-312 gm, 89-95 gm, 140-142 gm for NiTi closing coils, elastomeric chains, and Tie-backs respectively. The test group II (Listerine) had forces ranging from 307-312 gm, 72-77 gm, 129-130 gm for NiTi closing coils, elastomeric chains, and Tie-backs respectively and the test group III (Povidone-iodine) had forces ranging from 307-312 gm, 85-89 gm, 136-139 gm for NiTi closing coils, elastomeric chains and Tie-backs respectively.

However, the previous researches were done by Nattrass et al. [3], Larrabee et al. [6], De Genova et al. [9], Angolkar et al. [4], Luet al. [15], Cox et al. [14], Kuster et al. [11] made it clear that products studied in vitro have significantly less force decay when compared to those studied in vivo. The compound effect of in vivo studies could result in higher force levels than those seen in this in vitro study. This Study was carried out in a wet environment, wherein the elastomeric modules and Tie-back exposed to Listerine showed the highest force decay. While the elastomeric modules and Tie-back exposed to Povidone-iodine showed a similar force reduction when compared to artificial saliva over time. The drawbacks of this experiment was, it is an in-vitro study, which does not include simulate the oral environment on the products such as pH fluctuation, temperature, enzymatic and microbial action. Further studies should be carried out to reproduce the complex mechanism of orthodontic tooth movement that occurs when fixed appliances are placed in the oral cavity and the effects of oral environmental factors such as pH, temperature, enzymatic and microbial action. This study showed that the force decay of NiTi closing coils is not influenced by the different solvents. Whereas elastomeric chains and tiebacks exposed to Listerine had increase force degradation when compared to artificial saliva and Povidone-iodine mouth wash.

4. CONCLUSION

From this, in vitro study, we conclude that: The residual tensile strength in percentage on the 28th day in artificial saliva was significantly higher in NiTi closing coils when compared to elastomeric chains and tie-backs, Listerine Mouth Wash and Povidone-iodine rinse showed significantly higher force degradation in products such as elastomeric chains when compared to NiTi closing coils and tie-backs on the 28th day. Therefore, we can conclude that different mouthwashes effect the force decay of different products used for retraction. Applied to clinical conditions: When the force degradation was compared from the initial day to the 28th day, the force measured on 21st day for elastomeric chains was insufficient to cause tooth movement. The tensile force of NiTi closing coils was not effected by different solvents. Hence, it is advised to change elastomeric chains after every 3 weeks during retraction.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pithon MM, Santana DA, Sousa KH, Farias IM. Does chlorhexidine in different formulations interfere with the force of orthodontic elastic. Angle Orthod. 2013;83: 313-318.
2. Bradal PAP, Olympio KPK, Bastos JRM, Henriques JFC, Buzalaf MAR. Education and motivation in oral health-preventing disease and promoting health in patients undergoing orthodontic treatment. Dental Press J Orthod. 2011;16(3):95-102.

3. Natrass C, Ireland AJ, Sherriff M. The effect of environmental factors on elastomeric chain and nickel titanium coil springs. Eur J Orthod.1998;20:169-176.

4. Angolkar PV, Arnold JV, Nanda RS, Duncanson MG Jr. Force degradation of closed coil springs: An in vitro evaluation. Am J Orthod Dentofacial Orthop. 1992;102:127-133.

5. Josell SD, Leiss JB and Rekow ED. Force degradation in elastomeric chains. Semin Orthod. 1997;3:189-197.

6. Larrabee TM, Liu SS, Torres-Gorena A, Soto-Rojos A, Eckert GJ and Stewart KT. The effects of varying alcohol concentrations commonly found in mouth rinses on the force decay of elastomeric chain. Angle Orthod. 2012;82:894-899.

7. Andreasen GF, Bishara S. Comparison of alastik chains with elastics involved with intra arch molar to molar forces. Angle Orthod. 1970;40(3):151-58.

8. Hershey HG, Reynolds WG. The plastic module as an orthodontic tooth-moving mechanism, Am J Orthod 1975;67(5): 554-62.

9. De Genova DC, McInnes-Ledoux P, Weinberg R, Shaye R. Force degradation of orthodontic elastomeric chains - A product comparison study. Am J Orthod. 1985;87(5):377-384.

10. Singh VP, Pokhrael PR, Pariekh K, Roy DK. Elastics in orthodontics: a review. Health Renaissance. 2012;10:49-56.

11. Kuster R, Ingervall B and Birgrn W. Laboratory and intraoral tests of the elastic chains. Eur J Orthod. 1986;8:202-208.

12. Baty DL, Volz JE, Von Fraunhofer JA. Force delivery properties of colored elastomeric modules. Am J Orthod Dentofacial Orthop. 1994;106(1):40-46.

13. Oshagh M, Ajami S. A comparison of force decay: elastic chain or tie-back method? World J Orthod. 2010;1:e45-e51.

14. Cox C, Nguyen T, Koroluk L, Ko CC. In-vivo force decay of nickel-titanium closed-coil springs. Am J Orthod Dentofacial Orthop. 2014;145(4):505-13

15. Lu TC, Wang W, Tarng TH, Chen JW. Force decay of elastomeric chains - A serial study - Part II. Am J Orthod Dentofacial Orthop.1993;104(4):373-377.

© 2021 Fatima et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/73204