SEJODR

Experimental evaluation of strength degradation of orthodontic chain elastics exposed to cigarette combustion smoke

Caio Ferraz [1]; Paula Mathias [1]; Matheus Costa [2]; Matheus Pithon [2]; Emanuel Braga [1]

1 Bahia Federal University, Brazil

2 Bahia State Southwest University, Brazil

ABSTRACT

Introduction: Effects of cigars in the performance of dental restorative materials have been largely investigated; however, no information about the role of smoking cigars in strength degradation of orthodontic elastics has been revealed.

Aim of the study: evaluate the effect of smoke derived from cigarette combustion on the strength degradation of orthodontic chain elastics.

Materials and methods: Four distinct elastics from two different manufacturers were evaluated: Maximum Power Chain Pearl (OTP) (OrthoTechnology); Maximum Power Chain Pearl Tone Blue (OTPB) (OrthoTechnology); Orthodontic Elastic Chain Gray (MG) (Morelli); Orthodontic Elastic Chain Crystal (MC) (Morelli). Elastic segments were distended and exposed for eight minutes, twice a day, with an interval of 12 hours to cigarette combustion smoke. Elastic tension was evaluated at baseline, 7, 14 and 21 days.

Results: the findings have shown that all elastics presented progressive tension reduction over the period evaluated. Statistically significant differences were evidenced from the baseline to 7 days and from 14 to 21 days period. The OTP and OTPB elastics presented greater initial tension when compared to the MG and MC elastics. This pattern was reproduced throughout the study periods. When test groups were compared to the control in the period of 21 days, it was observed that cigars combustion smoke reduced in a statistically significant manner the elastic strength in all groups tested. Relative comparisons between the tested samples and control in the period of 21 days indicated that smoke exposure promoted strength loss that varied from 7% (OTP) to 12% (OTPB).

Conclusion: experimental exposure to cigarette combustion smoke contributed to the strength degradation of orthodontic chain elastics in a period of 21 days.

Ferraz C, Mathias P, Costa M, Pithon M, Braga E. Experimental evaluation of strength degradation of orthodontic chain elastics exposed to cigarette combustion smoke. South Eur J Orthod Dentofac Res. 2020;7(1):12-15.

INTRODUCTION

The smoking habit is a relevant public health problem. According to the World Health Organization, one billion people already routinely used cigarettes twenty years ago, but for the first time, a decreasing trend has nowadays been verified.[1] It is widely known that cigars predispose to several diseases and can cause death. Smoking causes more deaths than AIDS, car accidents, alcoholism, homicide, illicit drugs, suicides or fire incidents.[2]

Corresponding Author:
Emanuel Braga
Faculdade Odontologia UFBA.
Av. Araújo Pinho, 62. Canela. Salvador Bahia, Brazil. 40110-040.
e-mail: emanuelbraga@hotmail.com

Cigars are also an important concern in the field of dentistry and it is also the dentist's role to guide patients about general health practices.[3] The dental literature is vast in reporting the unquestionable ill effects of the tobacco burn in the mouth.[4] Moreover, the effects of cigars on the performance of dental materials have also called great interest. Researches have been carried out to investigate the effect of smoking cigars in the color stability, pigmentation, luminosity, solubility and other factors of composites and other materials.[5-9] However, the accessed literature failed to provide information about the role of smoking cigars in strength degradation of orthodontic elastics.

Elastics are amorphous polymers formed of polyurethane material, presenting rubber and plastic characteristics.[10] Elasticity is defined as the ability of the elastic to return to its original dimensions

when subjected to deformation forces. The type of molecular attraction and the geometric pattern of the polymers determine this property[11], yet factors linked to the intraoral environment such as saliva pH, enzymes, diet, the physical action of teeth brushing, temperature variations, water and pigment absorption accelerate elasticity loss and strength degradation.[11,12] It is thus speculated that smoking habit can also interfere in the elastic properties and somehow affect the orthodontic treatment outcome. The aim of the present study was to evaluate in laboratory the effect of cigarette combustion on the strength degradation of orthodontic chain elastics of 2 different brands and colors.

MATERIALS AND METHODS

In the present investigation, four different elastics of two distinct manufacturers were tested: Maximum Power Chain Pearl (OTP) (OrthoTechnology, Tampa, USA / Batch: 300379); Maximum Power Chain Pearl Tone Blue (OTPB) (OrthoTechnology, Tampa, USA/ Batch: 312937); Orthodontic Elastic Chain Gray (MG) (Morelli, Sorocaba, Brazil/ Batch: 1919161); Orthodontic Elastic Chain Crystal (MC) (Morelli, Sorocaba, Brazil/ Batch: 1904375). The segments were carefully removed from the reels without being stretched and five loops were selected for each sample. Segment cutting was always done in the middle portion of the sixth link, leaving half a link at each of its ends, so that no damage to the structure of the elastic chains occurred during cutting.

The segments were then placed with a clamp in a previously prepared tube fitting 18 elastic segments each. The custom tubes are made with polyvinyl chloride (PVC) with small holes in a horizontal distance of 0.5 mm between them, for the purpose of inserting support rods made of stainless steel (0.7 mm), which served as hooks for the elastic chains setting. The inside part of the tubes is filled with self-curing acrylic resin in order to fix the rods. Therefore, two of the five connections will be introduced and distended by a vertical distance of 23.5 mm (Fig. 1). This methodology was based on previously published work by Pithon et al.[13-15]

The sample was divided into groups according to the periods to be tested: baseline, 7, 14 and 21 days. The elastics arranged on the tubes were immersed in artificial saliva at a temperature of 37ºC for the period of 1h before the beginning of the experiments, except for baseline measuring. Then, the tubes were removed from the container with artificial saliva, allowing the saliva to drain, and then positioned in the combustion device in which they remained for eight minutes twice daily, with an interval of 12 hours. After each experiment, samples were totally re-immersed in plastic containers with artificial saliva and kept in an incubator with a temperature of 37 ± 1°C, controlled by a thermostat and digital thermometer, simulating the temperature of the oral cavity. The saliva was changed twice a week. The combustion device (Fig. 2) consisted of a two-chamber container with an opening connecting the two parts. An air pump was used to provide constant airflow into the first chamber, where lit cigarettes were set. The smoke-filled air in the first chamber was drawn through the opening into the second chamber, where samples were positioned; another opening in the second chamber allowed air to escape. For each exposure, 10 cigarettes Marlboro (Philip Morris International Management, Curitiba, Brazil) were used. The Control group received sham exposure.

Specimens were finally removed from the tubes and mounted in testing machine after each experimental period. In order to evaluate the strength degradation, the chain elastics were removed from the hooks and placed in the universal calibration machine (AME-2kN; Filizola, São Paulo, Brazil) previously calibrated to the distance of 23.5 mm from the sensors. This setting ensured greater reliability of the data obtained. After each measurement, the machine was restarted and the values were recorded on a control chart.

Statistical Procedures

Descriptive statistics were employed and data were expressed as mean and standard deviation or median and interquartile range. Normality was accessed with the Shapiro-Wilk test. The Friedman test or ANOVA for repeated measures were used to evaluate in each group the strength degradation of the orthodontic elastics over time. The t-test for independent variables was used to test the differences between the groups at each moment. The level of significance was set at 5% ($\alpha = 0.05$). The data were tabulated and analyzed in IBM SPSS Statistics for Windows (IBM SPSS, 21.0, 2012, Armonk, NY: IBM Corp.).

Figure 1. *Elastics setting device*

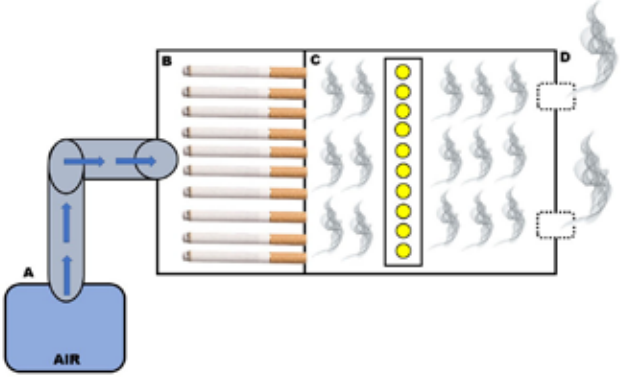

Figure 2. *Schematic representation of the cigars combustion device. A) Air pump. B) Lit cigarettes chamber. C) Sample chamber. D) Air/smoke release aperture.*

RESULTS

Table 1 shows the results in Newtons expressed as mean and standard deviations for the elastics tested (except for the Morelli Crystal that is expressed as a median and interquartile range). It was observed through the intragroup comparisons that all elastics presented progressive tension reduction over the period evaluated. Statistically significant differences were evidenced from the baseline to 7 days and from 14 to 21 days period. The OTP and OTPB elastics presented greater initial tension when compared to the MG and MC elastics. This pattern was reproduced throughout the study periods. When the test groups were compared to the control in the period of 21 days (Table 2), it was observed that the cigars combustion smoke decreased in a statistically significant manner the elastic strength in all groups tested. Figure 3 shows the relative comparisons between the tested samples and control in the period of 21 days indicating that the smoke exposure promoted strength loss that varied from 7% (OTP) to 12% (OTPB).

DISCUSSION

In Orthodontics, many kinds of elastics are used. Elastomeric chains are manufactured as connected chain reels, which can be cut to the desired number of links[16] and used conveniently in many situations.[17] The stretched chain enables potential energy to be converted into mechanical energy, thus promoting dental movement.[10]

Varied advantages are attributed to elastomeric chains such as color diversity, low cost, adequate biocompatibility, relative ability to keep forces after distortion, high flexibility and good tolerance by patients. Elastics chains are easy to be applied and removed and do not require patient cooperation. In addition, elastics have no relevant impairment in phonetic functions or oral hygiene.[17-19] Under specific circumstances, however, elastics show quick tensile force degradation, thus compromising treatment outcome.[20] Based on the exposure, researches are needed to clarify the elastics properties in varied oral conditions. The present study aimed at researching the effects of cigarettes combustion smoke exposure in the tensile force degradation of orthodontic chain elastics.

The results demonstrated that over time all groups presented reduction of elastic force. It was observed through the intragroup comparisons that all elastics presented progressive tension reduction over the period evaluated. Statistically significant differences were evidenced from the baseline to 7 days and from 14 to 21 days period. The OTP and OTPB elastics presented greater initial tension when compared to the MG and MC elastics. This pattern was reproduced throughout the study periods. Tensional loss is clinically observed and assumed as an intrinsic property of elastics.[21-24] The present study demonstrated; however, that exposure to cigarette combustion smoke decreased the elastics tensional force significantly ($p < 0.001$) in the period of 21 days, comparing to the control. The relative comparisons between the tested samples and control in the period of 21 days indicated that the smoke exposure promoted strength loss that varied from 7% (OTP) to 12% (OTPB).

Based on the assumption that elastics are not able to keep constant levels of tension over a long time, the present study

Table 1. *Elastic strength in Newtons according to the different periods. OTP (OrthoTechnology Pearl); OTPB (OrthoTechnology Pearl Blue); MG (Morelli Gray); MC (Morelli Crystal). Results are expressed as mean and standard deviation, except for MC expressed as median and interquartile range.*
**ANOVA for repeated measures (a,b,c results with same letters are not statistically different through Bonferroni test);*
† Friedman Test (a,b,c results with same letters are not statistically different through Wilcoxon test).

Elastic	Baseline	7 days	14 days	21 days	p
OTP	4,81 ± 0,30[a]	2,69 ± 0,34[b]	2,51 ± 0,39[b]	2,39 ± 0,38[c]	< 0,001*
OTPB	5,06 ± 0,44[a]	2,46 ± 0,29[b]	2,37 ± 0,25[b]	2,13 ± 0,27[c]	< 0,001*
MG	4,25 ± 0,44[a]	2,04 ± 0,17[b]	2,02 ± 0,16[b]	1,80 ± 0,18[c]	< 0,001*
MC	4,10 ± 0,60[a]	2,05 ± 0,30[b]	2,00 ± 0,15[b]	1,80 ± 0,25[c]	< 0,001†

Table 2. *Strength degradation in Newtons of the groups exposed to the combustion smoke and the control from the baseline to the period of 21 days. OTP (OrthoTechnology Pearl); OTPB (OrthoTechnology Pearl Blue); MG (Morelli Gray); MC (Morelli Crystal).*
**t-test for independent measures*

Elastic	Control	Smoke Exposure	Diference	p*
OTP	- 2,09 ± 0,44	- 2,42 ± 0,40	- 0,32	0,028
OTPB	- 2,32 ± 0,52	- 2,92 ± 0,44	- 0,60	0,001
MG	- 2,13 ± 0,46	- 2,45 ± 0,46	- 0,32	0,043
MC	- 1,91 ± 0,41	- 2,19 ± 0,44	- 0,28	0,051

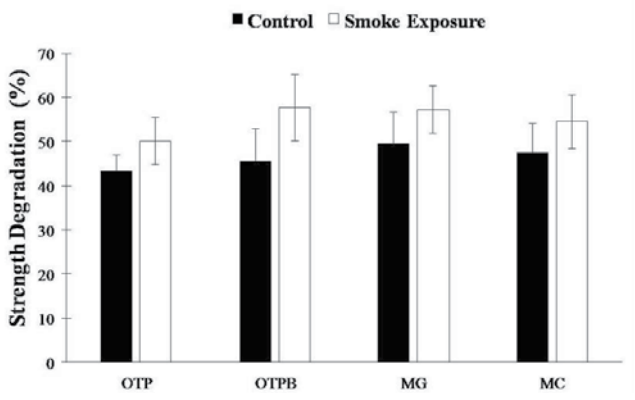

Figure 3. *Strength degradation of the groups exposed to the cigars combustion smoke and the control from the baseline to the period of 21 days. OTP (OrthoTechnology Pearl); OTPB (OrthoTechnology Pearl Blue); MG (Morelli Gray); MC (Morelli Crystal). Columns represent the mean percentage of strength degradations and bars represent the standard deviation.*

aimed at evaluating a period of 21 days, since this is often the recommended interval between orthodontic appointments.[17] Previously published papers also employed same approach[17,25], yet longer periods of testing are available in the literature.[11-13,15] Throughout the research period, the temperature was kept at 37 ± 1°C and immersed in artificial saliva. This care is essential to keep the laboratory study as close as possible to the conditions of the human mouth and reduce the influence of other factors.

The present research investigated the effect of cigarettes combustion smoke on elastics strength. The experimental burn chamber used is considerably large and no relevant raise in temperature could be noticed. The present findings may be attributed to the smoke effect solely. In respect to the effect of temperature on elastics tensile force, a previous published study[18] showed that temperature of the environment appeared to significantly influence the degradation mechanism of polyurethane elastomers. Other research reported that hot liquids reduced the elastic force of latex and non-latex elastics even when cycled for short periods of time. Moreover, distinct elastics produced by the same company showed different tensional results.[20] Because of complete different methods and aims, the findings shown by the studies mentioned above are not proper for comparison with the results brought by the present research. There is a varied sort of experimental methods and elastic types and features in the literature. The diversity of variables provides results that are valid under a particular condition. Moreover, it is assumed to be very difficult to control all the factors that can influence the results.[26]

The current research is a laboratory study and in the mouth conditions other key factors may play important roles. The present results should thus be interpreted with the right care. In addition, two exposure of eight minutes each were performed per day; however, time of smoke contact with mouth can vary greatly depending on individual smoking routine. Variations of temperature can be a critical aspect, since the mouth is a small cavity.

Finally, it is believed to be relevant for the orthodontist to comprehend the behavior of the materials to obtain proper clinical outcomes. Although tension loss occurred in a progressive manner for all groups, all elastics kept at the end of the time course, an adequate tensional force and were; therefore, indicated for use. Clinical researches are anticipated for better clarification whether the strength degradation observed in the present study has any potential implication in the treatment outcome.

CONCLUSIONS

Experimental exposure to cigarette combustion contributed in a statistically significant manner for the strength degradation of orthodontic chain elastics in a period of 21 days.

CONFLICT OF INTEREST

The authors of the present article declare no conflicts of interest.

REFERENCES

1. WHO global report on trends in prevalence of tobacco use 2000-2025, third edition.Geneva: World Health Organization; 2019a. https://bit.ly/2RhaeN2
2. Sharara FI, Seifer DB, Flaws JA. Environmental toxicants and female reproduction. Fertil Steril 1998;70(4):613–22.
3. Baboni FB, Guariza Filho O, Moreno AN, Rosa EA. Influence of cigarette smoke condensate on cariogenic and candidal biofilm formation on orthodontic materials. Am J Orthod Dentofacial Orthop 2010;138(4):427-34.
4. Van der Velden U, Varoufaki A, Hutter JW, Xu L, Timmerman MF, Van Winkelhoff AJ, et al. effect of smoking and periodontal treatment on the subgingival microflora. A retrospective study. J Clin Periodontol 2003;30(7): 603–610.
5. Alkhatib MN, Holt RD, Bedi R. Smoking and tooth discolouration: findings from a national cross-sectional study. BMC Public Health 2005;5(27):1-4.
6. Bazzi JZ, Bindo MJ, Rached RN, Mazur RF, Vieira S, de Souza EM. The effect of at-home bleaching and toothbrushing on removal of coffee and cigarette smoke stains and color stability of enamel. JADA 2012;143(5):e1-e7.
7. Mathias P, Costa L, Saraiva LO, Rossi TA, Cavalcanti AN, da Rocha Nogueira-Filho G. Morphologic texture characterization allied to cigarette smoke increase pigmentation in composite resin restorations. J Esthet Restor Dent 2010;22(4):252–261.
8. Mathias P, Rossi TA, Cavalcanti AN, Lima MJ, Fontes CM, Nogueira-Filho Gda R. Cigarette smoke combined with staining beverages decreases luminosity and increases pigmentation in composite resin restorations. Compendium of continuing education in dentistry (Jamesburg, N.J.: 1995) 2011;32(2):66-70.
9. Mathias P, Silva LD, Saraiva L de O, Costa L, Sampaio MD, de Araujo RP, et al. Effect of surface sealant and repolishing procedures on the color of composite resin exposed to cigarette smoke. General dentistry. 2010;58(4):331-5.
10. Yagura D, Baggio PE, Carreiro LS, Takahashi R. Deformation of elastomeric chains related to the amount and time of stretching. Dental Press J Orthod. 2013;18(3):136-42.
11. Alexandre LP, Oliveira Júnior Gd, Dressano D, Paranhos LR, Scanivi MA. An evaluation of the mechanical properties of elastic ligatures and power chains in orthodontics. Revista Odonto. 2008;32(16):53-63.
12. Weissheimer A, Locks A, Menezes LM, Borgatto AF, Derech CA. In vitro evaluation of force degradation of elastomeric chains used in Orthodontics. Dental Press J Orthod. 2013;18(1):55-62.
13. Pithon MM, Barreto JR, Andrade CSS, Novaes FP, Luz MN, Andrade ADV, et al. Do alcoholic beverages interfere in the force of orthodontic elastics? Rev Odontol UNESP. 2014;43(3):191-195.
14. Pithon MM, Rodrigues AC, Sousa EL, Santos LP, Soares Ndos S. Do mouthwashes with and without bleaching agents degrade the force of elastomeric chains? Angle Orthod. 2013;83(4):712-7.
15. Pithon MM, Santana DA, Sousa KH, Farias IM. Does chlorhexidine in different formulations interfere with the force of orthodontic elastics? Angle Orthod. 2013;83(2):313-8.
16. Larrabee TM, Liu SS, Torres-Gorena A, Soto-Rojas A, Eckert GJ, Stewart KT. The effects of varying alcohol concentrations commonly found in mouth rinses on the force decay of elastomeric chain. Angle Orthod. 2012;82(5):894-9.
17. Kochenborger C, Silva DL, Marchioro EM, Vargas DA, Hahn L. Assessment of force decay in orthodontic elastomeric chains: An in vitro study. Dental Press J Orthod. 2011;16(6):93-9.
18. Martins MM, Mendes AM, Almeida MAO, Goldner MTA, Ramos VF, Guimarães SS. Comparative study of different colors of molded elastomeric ligatures. R Dental Press Ortodon Ortop Facial. 2006;11(4):81-90.
19. Souza EV, Mendes AM, Almeida MAO, Quintão CCA. Force decay rate of orthodontic elastomeric ligatures. R Dental Press Ortodon Ortop Facial 2008;13(2):138-145.
20. Motta AFJ, Cury-Saramago AA, Nojima LI. In vitro evaluation of force delivered by elastomeric chains. Dental Press J Orthod. 2011;16(6):36.e1-8.
21. Ash JL, Nikolai RJ. Relaxation of orthodontic elastomeric chains and modules in vitro and in vivo. J Dent Res. 1978;57(5-6):685-90.
22. 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):377-84.
23. Hershey HG, Reynolds WG. The plastic module as an orthodontic tooth-moving mechanism. Am J Orthod. 1975;67(5):554-62.
24. Huget EF, Patrick KS, Nunez LJ. Observations on the elastic behavior of a synthetic orthodontic elastomer. J Dent Res. 1990;69(2):496-501.
25. Teixeira L, Pereira B do R, Bortoly TG, Brancher JA, Tanaka OM, Guariza-Filho O. The environmental influence of Light Coke, phosphoric acid, and citric acid on elastomeric chains. J Contemp Dent Pract. 2008;9(7):17-24.
26. Paige SZ, Tran AM, English JD, Powers JM. The effect of temperature on latex and non-latex orthodontic elastics. Tex Dent J. 2008;125:244–249.