

Force decay in orthodontic elastomeric chains after immersion in disinfection solutions

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Abstract

Aim: To evaluate the force decay of orthodontic elastomeric chains after immersion in disinfecting solutions. **Methods:** One-hundred and fifty segments of elastomeric chains were divided in 3 groups: Control group – no disinfection; Chlorhexidine group - disinfection in 0.12% chlorhexidine digluconate solution; and Peracetic acid group - disinfection in 0.2% peracetic acid solution. Elastomeric chains of 14 mm were stretched up to 20 mm and the given force (kgf) was evaluated in an Instron universal testing machine at the following intervals: 1 h, 1 day, 7, 14, 21 and 28 days after the immersion in the disinfecting solutions. Data (kgf) were analyzed statistically by Analysis of Variance and Tukey's test at a 5% significance level. **Results:** Both groups presented similar force decay along 7 days and remained stable up to 28 days. Force degradation was observed in the first hours of activation (~50%). **Conclusions:** It may be concluded that there were no significant differences among the investigated groups, in most interval times, indicating that both chemical solutions can be used for previous disinfection of orthodontic elastomeric chains.

Keywords: orthodontic space closure; disinfection; chlorhexidine; peracetic acid.

Introduction

The use of elastic chains is widely spread among orthodontists, as they are practical, effective, available in a wide range of colors, low cost and patients find them comfortable to use. Their application in Orthodontics is very extensive and their main characteristic is the ability to return to their original size after deformation. However, several studies have shown that over time the release forces of the elastics are gradually reduced in a process called deflection¹⁻⁴. This deflection may be influenced by many factors such as exposure to heat, saliva, mastication and pre-stretch^{1-2,5-8}.

As occurs with all dental materials, the elastic chains are subject to contamination, especially since they are manufactured in spool format. Spool dispensers were developed with the purpose of reducing contamination, but another option would be to immerse them in chemical solutions.

Previous studies have been conducted to assess the force loss of elastic chains when immersed in glutaraldehyde-containing solution. It was found that force loss would be non-significant when they were immersed for 30 min (disinfection procedure), but significant when immersed for 10 h (sterilization process)^{5,8-9}. Another option for disinfection and cold sterilization is the peracetic acid, which has been used instead of glutaraldehyde, because it is biodegradable, atoxic, non allergenic, it works even in the presence of organic matter and has no teratogenic or carcinogenic effects¹⁰⁻¹².

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Chlorhexidine is usually indicated as the first-choice antiseptic in Dentistry and it is widely used due to its capacity to reduce microbial loads such as *Streptococcus mutans*, *Lactobacilli* and *Candida albicans*. The use of 0.12% chlorhexidine as a disinfecting agent has been proposed for base plates of removable orthodontic appliances, among other substrates¹³. A previous study suggested that chlorhexidine solutions in different concentrations have no significant influence on the force degradation of elastic chains¹⁴. However, the comparison of chlorhexidine and peracetic acid effects on force of elastic chains after disinfection remains not assessed.

The study hypothesis is that force decay may occur in orthodontic elastomeric chains subjected to disinfection and sterilization procedures using 0.12% chlorhexidine digluconate and peracetic acid-containing solution, respectively.

Material and methods

One-hundred and fifty samples of orthodontic elastomeric chains (3M/Unitek, Sumaré, SP, Brazil) were used. All samples showed medium conformation, gray color and were within the expiry date. They were stored according to the manufacturer's instructions up to the time of use.

The elastomeric chain segments were divided in 3 experimental groups (n=50), according to the immersion period and disinfectant solution: Control group – elastomeric chains not immersed in disinfectant solution; Chlorhexidine group – elastomeric chains immersed in 0.12% chlorhexidine digluconate solution (Periogard, Colgate, São Paulo, SP, Brazil) for 10 min¹⁵ and Peracetic acid group – elastomeric chains immersed in 0.2% peracetic acid-based solution for 30 min¹⁶. Samples were removed from the solution and washed with purified water (1 min) for complete removal of the disinfectant residues.

The elastomeric chains were cut into 14 mm long segments (equivalent to four links). Samples were first placed in a universal testing machine (4411 Canton, USA) and subjected to distention to a distance of 20 mm at a speed of 5 mm/min¹⁷. Fifteen acrylic plates 40 mm long, 14 mm deep and 3 mm thick were fabricated. Ten markings were made on the length of each side, placed equidistantly 20 mm apart. The plates were perforated on the markings and metal posts were adapted in each orifice (Figure 1). Each plate was identified with the manufacturer's brand name and the solution in which it was immersed. All samples were placed stretched on acrylic plates, immersed in artificial saliva and their forces were measured at time intervals of 1 h, 1 day, 7 days, 14, 21 and 28 days after immersion.

Force data (kgf) were submitted to analysis of variance followed by Tukey's test at a level of significance of 5%. The assessed factors were: disinfecting treatment and storage time.

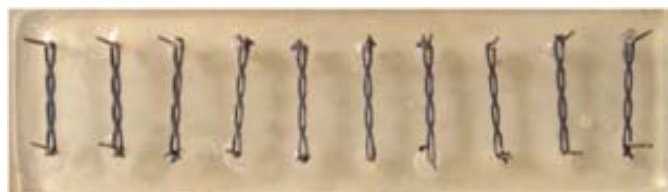


Fig. 1. Plate with metal posts and elastic chains in position.

Results

According to the obtained results, a statistically significant reduction ($p < 0.05$) in the force values was found for the three groups up to the 7-day period (Table 1). The three groups did not differ statistically among them ($p > 0.05$) at the initial and on the following time points: 1 h, 14, 21 and 28 days ($p > 0.05$). The control group did not differ from the other two groups at 24 h ($p > 0.05$). Within 24 h, only the disinfection groups differed from each other ($p > 0.05$). The control group showed higher mean force and differed statistically from peracetic acid in the 7-day time interval ($p < 0.05$).

For the samples not immersed in disinfectant solutions, from the 7th day of immersion on, the mean values continued to decrease, but no difference was found between the time intervals of 7 and 14-days or between 21 and 28 days ($p > 0.05$). The 7 and 14-day time intervals differed statistically from the 21 and 28 day time intervals ($p < 0.05$). For samples immersed in chlorhexidine and peracetic acid, mean values also continued to decrease from the 7th day of immersion on, but there was no difference among all other time intervals ($p > 0.05$).

The percentage reduction in force values of elastomeric chains according to the period of analyses was similar for each group (Figure 2). When compared with the initial assessment period, there was a percentage reduction in the force values following the analyzed time points.

Discussion

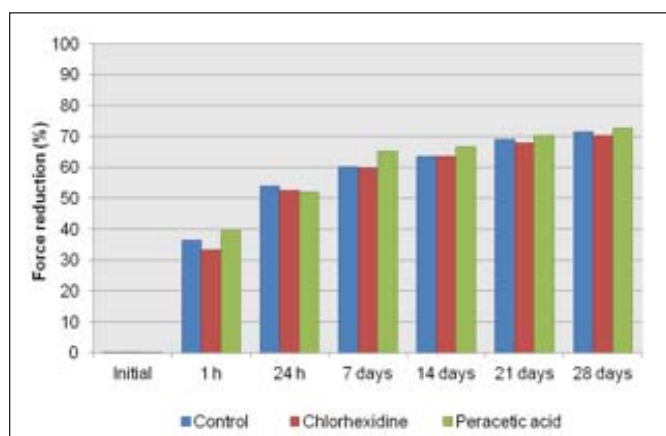
In the present study, the elastic samples were continuously stretched to 20 mm; this stretching was based on the literature, with the purpose of simulating the mean distance from the maxillary canine to the mesial limit of the maxillary first molar on the same side of the dental arch¹⁸. The reason for stretching the elastics to this length is because it is a common procedure in orthodontic treatments to promote initial retraction of the canines. Furthermore, elastomeric chains were assessed from an immediate time up to 28 days since this may be considered the average time for replacement of elastics in Orthodontics¹⁹.

Over the last few decades, the habits of professionals in the field of Dentistry had to be changed due to the increased incidence of transmissible diseases. Questions related to infection control and biosafety came into focus in a new way, as they had not been subjected to such strict criteria as they are today. Despite its minimally invasive nature, Orthodontics is a specialty with a high risk of cross-infection due to the use of perforating and cutting instruments, air jets and the high turnover of patients. On the other hand, the elastics may suffer significantly greater force degradation when they are analyzed in humid conditions, with exposure to heat, incorporation of dyes, disinfection and sterilization with glutaraldehyde, pre-stretching, among others^{5,8,20-23}. Thus, in the present study, the elastic chains were immersed in two

Table 1. Mean force values in kgf of orthodontic elastomeric chain as function of disinfectant solutions and storage time (Standard Deviation).*

Time point	Control group	Chlorhexidine	Peracetic acid
Initial	289.0 (10.5) a, A	274.0 (31.4) a, A	295.9 (16.8) a, A
1 h	183.8 (20.5) b, A	181.2 (14.5) b, A	178.5 (13.3) b, A
24 h	133.1 (11.9) c, AB	128.2 (15.3) c, B	141.6 (15.9) c, A
7 days	114.8 (16.8) d, A	109.0 (15.8) d, AB	102.8 (14.6) d, B
14 days	105.2 (12.4) d, A	98.7 (12.8) d, A	98.8 (14.7) d, A
21 days	89.5 (14.9) e, A	86.9 (13.5) d, A	87.8 (14.8) d, A
28 days	82.6 (14.2) e, A	80.4 (12.4) d, A	81.0 (12.5) d, A

* Means followed by lowercase letters vertically are statistical comparisons regarding time of analysis; means followed by uppercase letters horizontally indicate the statistical comparisons in the same row.

**Fig. 2.** Percent decrease (%) orthodontic elastomeric chain force of all groups according to the storage time.

solutions, chlorhexidine and peracetic acid, with the purpose of providing disinfection and sterilization and assessing the influence of these substances on the degradation of forces generated by elastic chains.

Samples that remained immersed in chlorhexidine for 10 min were disinfected, and the samples immersed in peracetic acid for 30 min were sterilized according to the manufacturer. It is known that force loss suffered by synthetic elastics is significantly greater when tested in humid conditions than when assessed under dry conditions. After the disinfecting and sterilizing procedure, all the samples remained immersed in artificial saliva²⁴.

As reported in a previous study, the absorption of liquids causes alterations in the elastomeric chains²⁵. Studies using glutaraldehyde have shown that the time of immersion is important in the significant decrease in force released by the elastics, as observed in the present study in which the samples that showed the greatest force decreases were immersed in peracetic acid. This may be because this product requires a 30-minute immersion time in order to achieve sterilization, and is absorbed in greater quantity than the chlorhexidine solution, which remained in contact with the sample for only 10 min and disinfection was achieved^{5,21}. Another factor that justifies these data could be the acidity of the solution, since acid solutions also accelerate degradation of elastic chains and consequently decrease the force released, as occurred with all the samples immersed in peracetic acid²⁰.

The tested elastics showed significant decrease in the amount of force generated after one hour of constant activation, recording percentages of 33.2 to 39.5%. These values continued to decrease, reaching 53.9% after 24 h stretching. This is in agreement with the findings of studies that showed a loss of 50% to 70% of the initial force on the first day of use, with the elastics having only 30-40% of their original force in the third week^{4,19}. Interestingly, a previous study²² found a 66.07% decrease in the forces generated by color elastic ligatures. In this study were found higher values, but this was attributed to the fact that the manufacturers included dyes in the elastic ligatures.

Several factors made it difficult to quantify the force needed to promote the dental movements required to close gaps. However, better clinical results have been found with forces ranging between 150 g and 200 g. Following this reason and considering the force values found in the present study on the first day of activation, at the end of the 28th day the elastics would have lost their effectiveness to close spaces, and should have been replaced in a shorter period of time, in order to take better advantage of their properties¹⁹.

The control group (immersed only into artificial saliva) and experimental groups (chlorhexidine and peracetic acid) showed similar results, indicating that disinfection and sterilization of elastics may be recommended because, in addition to being fast procedures, they also led to minimal tensile loss when compared with the control group immersed in artificial saliva.

In conclusion, the disinfection with chlorhexidine and peracetic acid did not affect the degradation of elastomeric chains used in this study.

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