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ForcedegradationofElastomericchain after mechanical brushing

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Abstract:

Aim: The aim of this *in vitro* study was to evaluate the force degradation of five elastomeric chains that were evaluated for 10 minutes simulated by mechanical brushing.

Materials and Methods: Initially, the elastomeric chain of 20mm long was immediately stretched up in an Instron and the force was measured.orthodontic elastomeric chains were cut into 20 mm long segments (five links). Afterwards, all samples were placed stretched on rectangular acrylic cubes. The acrylic cubes allowed the orthodontic elastomeric chain segments stretched. The acrylic cubes with e chain were submitted to a simulated mechanical brushing technique. The mechanical brushing procedure was carried out. After the simulated brushing procedure, the specimens were rinsed with air/water. The force (gf) values were obtained using the testing machine (Instron).

Results: The force mean values are shown in Table 1. Significant differences between the orthodontic elastomeric chains ($p<0.00001$) and tensile strength ($p<0.00001$) were detected. The interaction between orthodontic elastomeric chains and tensile strength ($p<0.00001$) factors were significant.

Conclusion: Within the limitations of this in vitro study, mechanical brushing significantly reduced the force and elasticity of orthodontic elastomeric chains, potentially affecting treatment efficiency and requiring more frequent replacement or reactivation. Despite this force degradation, elastomeric chains remain a practical and cost-effective option in orthodontics, although further long-term clinical studies are needed.

Keywords: orthodontics, ligation, e chain, mechanical brushing

Introduction:

The elastomeric chains are used extensively in orthodontics for intra-arch teeth movement. They are practical, low cost, and comfortable for patients, effective in diastemas closing, correcting rotations, shifting the midline, achieving general space closure and removal requires little chair time for the dentist (1). Forces delivered by elastomeric chains are not constant and degrade overtime. The degree of degradation could result in forces that fall below the threshold value, precluding any therapeutic effect.However, the elastomeric chains deteriorate rapidly in the oral environment and do not produced continuous force for teeth movement for a long period of time(2).A rapid loss of force in an elastomeric chain causes inefficient tooth movement, which will result in an increased number of consultations for reactivate the appliance(3). Previous studies showed that the force degradation of different orthodontic elastics may be influenced by many factors, such as time, mastication, pre-stretch, exposure to heat, colour, temperatures ,saliva ,different pH ,and alcohol concentrations in mouthwashes.(4)

For the other hand, beyond mouthwashes the use of mechanical brushing during orthodontics treatment is largely recommended with the goal for the maintenance of oral hygiene, reduction in the frequency of caries lesions ,and dental biofilm. Nevertheless, little is known about the mechanical brushing effect on the force degradation of elastomeric chains(5).

Therefore, the aim of this *in vitro* study was to evaluate the force degradation of five elastomeric chains that were evaluated for 10 minutes simulated by mechanical brushing.

Materials and methods:

The elastomeric chains are manufactured in a single continuous chain, they were cut to a standard length. Initially, the elastomeric chain of 20mm long was immediately

stretched up shown in figure 1 in an Instron and the force was measured in gf. orthodontic elastomeric chains were cut into 20mm long segments (five links). Afterwards, all samples were placed stretched on rectangular acrylic cubes which is shown in figure 2. The acrylic cubes allowed the orthodontic elastomeric chain segments stretched. The two most lateral stainless steel pins were spaced 20 mm from each other. The acrylic cubes with e chain were submitted to a simulated mechanical brushing technique using a mechanical device in which every sample was individually brushed. The mechanical brushing procedure was carried out with soft nylon bristles fixed to the device with cyanoacrylate glue. Care was taken to ensure that the bristles were perpendicular to the surface of each specimen and touched the surface evenly. A slurry of toothpaste and deionized water in a 50:50 (w/w) was used. The volume of slurry needed to maintain a constant supply of abrasive between brush and the specimen surfaces were provided by 37.5 grams of dentifrice and deionized water (75 grams total). The specimens were brushed for 840 times at 1.5 Hz using a brush head force of 350 grams .After the simulated brushing procedure, the specimens were rinsed with air/water spray for 30 s and stored in 100% humidity until force (gf) values were obtained using the testing machine (Instron) shown in figure 3.

Figure :1

Figure:2

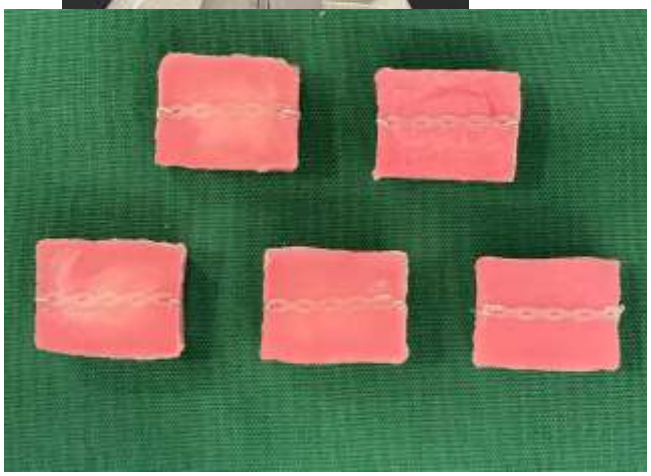


Figure 3

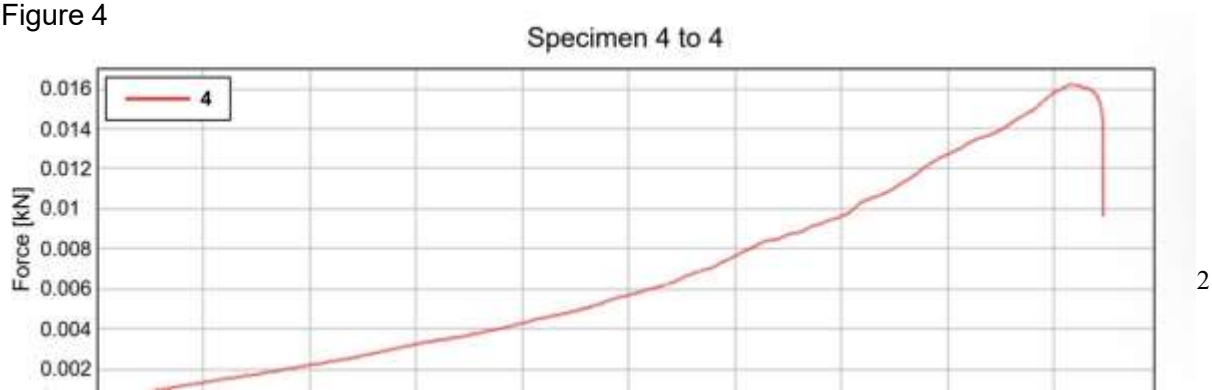
Results:

The force mean values are shown in Table 1. Significant differences between the orthodontic elastomeric chains ($p<0.00001$) and tensile strength ($p<0.00001$) were detected. The interaction between orthodontic elastomeric chains and tensile strength ($p<0.00001$) factors were significant.When the groups were evaluated individually over time (Table 1) a statistically significant reduction in the force was found for all orthodontic elastomeric chain types.

Table 1

	Maximum Force [N]	Tensile stress at Tensile strength [MPa]	Tensile strain (Displacement) at Break (Standard) [%]
3	16.48	2570.97	78.63
4	16.22	2535.13	94.61
5	16.49	2575.13	87.42
6	16.88	2631.66	94.48

Figure 4



Discussion:

Elastomeric chains are important and commonly used in orthodontics to facilitate tooth biomechanics mainly due to strength transmission to the teeth. However, these materials are not ideal, because during the activation period of the treatment the force generated diminishes gradually. Several studies have tried to establish the mechanical and environmental factors, such as humid conditions, exposure to the heat, pre-stretching, incorporation of dyes, and disinfection and sterilisation that can contribute to the force degradation of orthodontic elastics.
Other study show methods that are used in this laboratory to simulate an intra-arch use of orthodontic elastomeric chains after immersion with deionized water at a 37°C since a basic environment preserves the force of the orthodontic elastomers compared to acidity of solution and high temperature that could potentially reduce the force. Previous study showed that the water bath testing is a more realistic environment used for large-scale testing of orthodontic elastomers than in air . However, they may only be adequate for short-term test.On the other hand, the dynamic testing estimates distance changes and causes a larger decrease in force early in testing of the elastics.

Previous studies showed that the greatest loss of force in elastomeric chains occurred after 24 hours of 46% to 49% and the force continued to decrease from 64% to 71.61% after 28 days. Other study showed that elastomeric chains exhibited a high percentage of force loss 42.18% to 53.38% during the first 24 hours, but after the force decay continued progressively 66.30% to 86.48% until 28 days.Another study showed that the force decay over time with 48.2% after 1 day and 59.7% after 28 days in relation to initial period in water. In this same line,. showed that elastomeric chains decreased significantly in the amount of force generated after one day, around 53.9%.
These values continued to decrease, reaching 71.42% after 28 days. The reduced elasticity in association with nearly constant forces suggests that the elastomeric chains begin to become brittle and lose elasticity after a short time. The force degradation is significant during orthodontic treatment, and it may depend on the magnitude of the force and the precision desired by the clinician. However, there does not exist consensus in the literature about this value but 10% difference is a measure that could be clinically significant for elastomeric chains. According to Kersey et al. 10% is probably a reasonable number and should be kept in mind when discussing the results above and relating them to the clinical setting, but the force was measured only until 24 hours.

Conclusion:

Within the limitations of this *in vitro* study, orthodontic elastomeric chains exhibited a significant reduction in force after simulated mechanical brushing. Mechanical

brushing influenced the tensile properties and force delivery of the elastomeric chains, indicating that routine brushing procedures may contribute to force degradation during orthodontic treatment. Although elastomeric chains remain effective for clinical tooth movement, the reduction in force over time may affect the efficiency of treatment and may require more frequent replacement or reactivation of the chains. Therefore, clinicians should consider the potential impact of mechanical brushing on elastomeric chain performance while planning orthodontic force application and maintenance protocols.

The results of the present study suggest that mechanical brushing, along with other environmental and oral factors, can accelerate the deterioration of elastomeric chains and reduce their elasticity over time. This reduction in force may lead to decreased effectiveness of orthodontic tooth movement and may require more frequent replacement or reactivation of the chains during treatment. Despite the force degradation observed, elastomeric chains continue to remain a practical and commonly preferred orthodontic material because of their ease of use, patient comfort, and cost-effectiveness. Further long-term clinical studies are recommended to evaluate the influence of different brushing techniques, dentifrices, and oral conditions on the force decay behavior of orthodontic elastomeric chains.

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(1,2,4–7)

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