

Force degradation of different elastomeric chains and nickel titanium closed springs

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Abstract

Aim: The purpose in this study was to evaluate the degradation force of conventional synthetic orthodontic elastics and synthetic orthodontic elastics with memory properties. **Methods:** Specimens of each material (Plastic chain, Memory chain and Closed spring NiTi) were stretched and adapted to the test specimens composed of resin plates and orthodontic wires, simulating retraction units. Degradation force was verified in an Instron universal test machine at the following intervals: 1, 2, 18, 24, 48 h; 7, 14, 21, and 28 days. Data (gF) were analyzed statistically using Friedman and Kruskal-Wallis tests at 5% significance level. **Results:** It was observed a significant force reduction of Plastic chain and Memory chain after 2 h ($p < 0.05$). For NiTi spring significantly force reduction was observed after 18 h, but no significant change was showed up to 21 days. NiTi spring showed force significantly higher than synthetic elastomeric materials ($p < 0.05$). There was no significant difference between Memory chain and Plastic chain up to 24 h. However, from 48 h to 21 days Memory chain showed force significantly higher than Plastic chain. **Conclusions:** There was higher force degradation in the synthetic elastomeric materials in comparison with NiTi springs, which allows the preferential indication of these space closure jigs for clinical use.

Keywords: orthodontics, biomechanics, tensile strength, elastomeric chains, closed nickel titanium.

Introduction

Interdental space closure is a common procedure in daily orthodontic clinical practice. In this context, different space closing systems have been proposed¹⁻⁵. Although a great deal is known about these systems, several studies are still being conducted in search of the ideal interdental space closure system. There is literary consensus in the sense that the ideal space closure mechanism should have mechanical properties that provide a light and continuous force that closes the orthodontic space in the shortest possible time^{3,6-8}. Firstly, this type of force would have the advantage of causing the least possible periodontal and root trauma, in addition to reducing the time of orthodontic treatment.

In this context, many space closure mechanisms have been suggested, among these elastomeric materials and closed NiTi springs. Elastomers have been used more frequently, as they are more practical and less costly. However, force degradation studies have proven that the elastomers lose a large part of their force generating capacity with the passage of time^{1-2,9-15}. The environment and temperature in which the elastic acts also interfere considerably in maintaining

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the properties of this type of material. It is known that elastics conserved in a humid environment and exposed to higher temperatures suffer greater reduction on their force generating capacity⁵. However, NiTi springs with shape memory may generate lower and continuous forces and be less influenced by the humidity and pH of the environment^{11-12,16-20}.

Synthetic orthodontic elastics with memory chain have been launched to the dental market. These elastics are used for intra-arch space closure and are low cost in comparison with the NiTi spring used for the same purpose. Thus, the aim of this study was to evaluate the degradation force suffered by conventional synthetic elastics, synthetic elastics with memory chains and NiTi springs during 28 days when exposed to an environment similar to the oral cavity.

Material and methods

Fifty samples were obtained of each of the three materials to be tested: conventional elastomeric chain (Plastic Chain, American Orthodontics, Sheboygan, WI, USA), elastomeric chain with memory (Memory Chain, American Orthodontics) and closed NiTi spring (GAC, New York, USA).

To simulate the mechanism of orthodontic retraction, 15 plates (3 mm thick x 30 mm wide x 150 mm long) were made of resin, divided into 3 groups, each of which was composed of 5 plates according to the material to be tested. Into these plates, 10 pairs of stainless steel orthodontic wire pins measuring 1.2 mm in diameter (Morelli, Sorocaba, SP, Brazil) were inserted. The pins were arranged in parallel pairs. The samples were inserted into each pair in such a way that their tips were distended during the evaluated test periods (Figure 1).

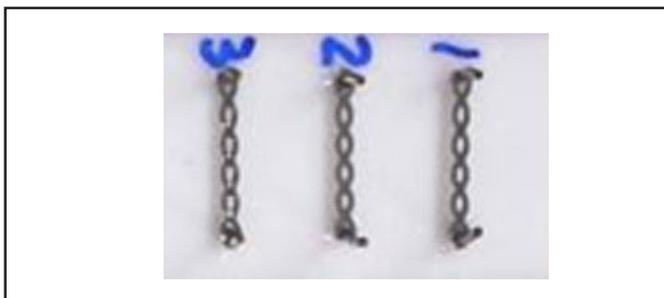


Fig. 1 - Test specimen (Plastic chain) stretched on plate.

The force of the stretched samples was measured in a universal test machine (Instron Corp., Canton, MA, USA). The initial distention force of these samples was standardized close to 200 gf, the force recommended for retraction of the anterior segment of the arches^{4,7}. The amount of material in each tested elastomeric segment was also standardized at 6 links, so that the distension stress would be similar in all elastomeric segments. The samples were carefully transferred to the resin plates while they were still distended. To simulate the oral conditions, the plates containing the elastomeric chains and the NiTi springs were immersed in artificial saliva (Saliform; Fórmula e Ação, São Paulo, SP, Brazil) and

maintained at 37°C for 28 days.

At the time intervals of 1 h, 2 h, 18 h, 24 h, 48 h, 7 days, 14 days, 21 days and 28 days the samples were removed from the resin plates, which in turn were immersed in artificial saliva and kept in an oven. After this, the retraction force of each sample was measured. Data (gF) were analyzed statistically using Friedman and Kruskal-Wallis tests at 5% significance level.

Results

Table 1 shows the means obtained as a function of the groups under study and the periods of time. The three experimental groups were compared (Kruskal-Wallis test) according to each period of time, and the samples of each group were compared separately (Friedman test) at the experimental time intervals.

The forces of NiTi spring, Memory chain and Plastic chain are presented in Table 1. NiTi spring showed significantly higher force than synthetic orthodontic elastomeric in all periods. There was no significant difference between memory chain and Plastic chain up to 24 h. Moreover, no significant difference ($p > 0.05$) was found between Memory chain and Plastic chain up to 24 h ($p < 0.05$). However, from 48 h to 21 days, Memory chain showed force significantly higher ($p < 0.05$) than Plastic chain.

Figure 2 shows the force of the space closure materials over time (28 days). It was found a significant decrease on force of NiTi spring after 18 h, but the force remained constant up to 21 days. For Memory chain and Plastic chain synthetic elastomeric materials, it was verified a significant force reduction after 2 h, with a gradual decrease up to 28 days.

Table 1 - Median (1st and 3rd quartiles) of force (in gF) as a function of the groups under study and the two periods of time

Times	Force (gF)		
	NiTi Spring	Memory chain	Plastic chain
Initial	228.5 a,A	206.0 b,A	195.0 b,A
1 h	221.5 a,A	152.5 b,A,B	147.5 b,A,B
2 h	220.5 a,A	144.0 b,B,C	132.0 b,B,C
18 h	202.5 a,B	112.5 b,B,C	105.0 b,C,D
24 h	197.0 a,C	98.0 b,C	98.0 b,D
48 h	196.5 a,B,C	102.0 b,C	88.0 c,D,E
7 days	195.0 a,C	94.0 b,C,D	80.0 c,E,F
14 days	198.5 a,B,C,D	90.0 b,D,E	75.8 c,F,G
21 days	205.5 a,B,D	86.5 b,D,E	71.5 c,G
28 days	188.0 a,C,E	76.5 b,E	71.5 b,G

Means followed by different lowercase letters in the line, and capital letters in the column, differ statistically among them, by the Friedman and Kruskal-Wallis tests at a level of significance of 0.05%.

Discussion

In order to obtain increasingly effective tooth movements, that is, with maximum tooth movement associated with anchorage control; tooth inclinations and vertical and rotational forces control, and at the same time,

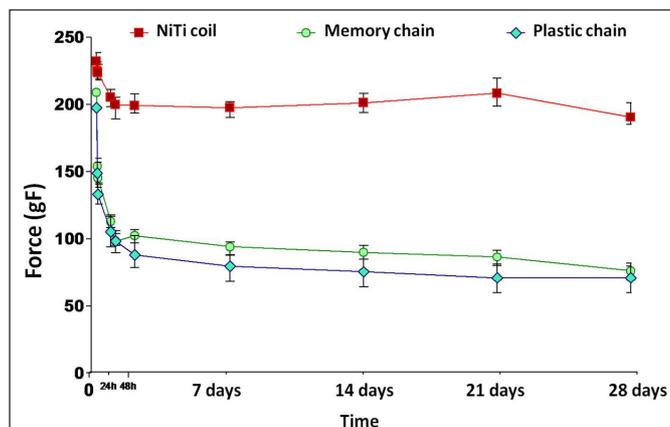


Fig. 2 - Force distribution (gf) of space closure materials over 28 days of evaluation.

ensuring the health of the teeth and periodontal tissues^{3,6-8,12}, this study compared the force degradation suffered by three materials: conventional elastomeric chain (Plastic chain), elastomeric memory chain (Memory chain) and closed NiTi springs. The initial force of all samples was standardized at close to 200 gf^{3-4,7}. In addition to standardization of force, the stretching of the materials was standardized in the case of the elastics, so that there would be no difference in the stress produced by the distention²¹.

The results of this study pointed out that the closed NiTi springs were more resistant to force degradation than the two types of elastomeric chains: conventional or with memory, according to Figure 1 and Table 1. These results are similar to those of previous studies^{11,16-18,20,22}. This characteristic of force maintenance is important, as it is related to a more physiological movement, with maximum amplitude and minimal aggression to the dental and periodontal tissues. The three retraction mechanisms lost force; however, force degradation in the spring was much lower than in the two types of elastics tested.

Another notable difference between the closed NiTi spring and the two types of elastics was the period in which there was the highest force degradation. In the NiTi spring, in addition to the degradation being lower, it was relatively constant during the 28 days of the experiment. Whereas, in both elastics there was expressive force degradation, with an approximate value of 100 gf in the first 24 h of the study, corroborating the results of other investigations^{1,9,13,23}, while the NiTi spring presented force degradation of approximately 25 gf in the same period. This is another result that allows to point the NiTi spring as the most appropriate device for exerting the characteristic of continuous “optimal force”, as the one that produces rapid tooth movement, without discomfort to the patient, and without side effects on tissues³.

Regarding the elastomeric chains, both types behaved in a very similar manner, suffering a remarkable initial degradation in the first 24 h, and maintaining a low, constant force degradation from 24 h up to 28 days of the experiment. It was noted that in this same period, from 48 h to 28 days of the experiment, Plastic chain showed force approximately

15 gf lower than the Memory chain. Nevertheless, the levels of force of these two types of elastics were equal at 28 days of the experiment.

During the literature review, no study about the force degradation of the elastomeric memory chain was found. Despite the lower force showed by synthetic elastomeric materials in comparison to NiTi spring, Memory chain showed lower force degradation than Plastic chain. Therefore, the force of Memory chain to tooth movement was closer than the clinical recommended (200 gf). From a clinical aspect, this results in faster tooth movement for Memory chain.

The closed NiTi springs were shown to have the best properties and best action for attaining more effective and less traumatic tooth movement, when compared with the two types of elastics tested. However, these springs are not used on a larger scale, probably due to their higher cost and the possibility, although remote, of causing soft tissue injuries in patients¹².

The preferential use of NiTi springs is suggested in patients who have a fully healthy periodontal status, and assiduously attend clinical appointments. In patients of this type, one could also use preferentially Memory elastomeric chains; however, with a force from 30 to 60% greater than necessary, in order to compensate for the rapid initial degradation suffered by these chains²⁴. Should the orthodontist be faced with a patient whose periodontitis has been stabilized, but with clinical attachment loss; or with a patient who does not attend consultations as frequently, the use of elastomeric chains calibrated at 200 gf for the anterior segment should be considered the most indicated device. Thus, smaller, but biologically acceptable movement will be achieved, without tissue damage to the tooth or the periodontium.

In conclusion, the three space closure system showed force degradations over 28 days; however, the force reduction of NiTi spring was the lowest among the materials. In the first day, force degradation of the elastomeric materials was even more significant, attaining the level of almost 26%, whereas the spring suffered a degradation of only 2.8%. After 28 days, a mean reduction of 16.1%, 63.2% and 64.0%, for the NiTi Spring, Memory chain and Plastic chain, respectively.

The closed NiTi springs were shown to be the most appropriate for orthodontic space closure treatment. Comparing elastomeric chains, memory chain should be preferred to plastic chain.

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