INFLUENCE OF DIFFERENT PHYSICAL AND CHEMICAL FACTORS ON FORCE DEGRADATION OF ORTHODONTIC INTRAORAL ELASTICS – A REVIEW

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Abstract: Correct selection of the dimension of orthodontic elastics, knowledge of their characteristics, monitoring of released forces at different time intervals, and good cooperation with patients are required for successful orthodontic treatment. During orthodontic therapy, elastics lose their initial strength due to various physical and chemical factors that change their structure. The purpose of this study is to determine, through the analysis of data from the available literature, whether there is a connection between the force degradation of different types of orthodontic intraoral elastics and the material from which they are made in different environments and time intervals.
Material and method: To realize the set goals, an electronic search of published studies on this issue was conducted through the PubMed and Google Scholar databases. The literature search was performed according to the PRISMA guidelines with the following main eligibility criteria: only studies published in English and studies conducted in human populations. Of particular interest were clinical studies, in vitro studies, prospective and retrospective studies, and systematic reviews and meta-analyses.
Results: there is clear difference of force degradation between latex and non-latex elastics especially after longer period of wear. Also the environment has influence on the force degradation of the elastics.
Conclusion: In the world literature, there are various data on the influence of various physical and chemical factors on the degradation of the strength of intermaxillary elastics. All conducted studies indicate a positive correlation between the degradation of the strength of different types of orthodontic intraoral elastics from different manufacturers and the material from which they are made, different environments and time intervals. The analysis of the data from the available literature indicated that the most important parameter in the loss of strength is the elastic stretching time.
Keywords: latex orthodontic elastics, non-latex orthodontic elastics, intermaxillary elastics and force degradation.

1. INTRODUCTION

Orthodontic extraoral and intraoral elastics for intermaxillary tooth traction are an integral part of orthodontic therapy and represent a source of force that serves to correct jaw relationships, close the spaces between teeth and correct the interdental environment. (Kardach 2019, Notaroberto 2018, Dubovská 2023, Rahpeyma 2014 & Oliveira 2017).

The correct choice of the dimension, the knowledge of their characteristics, monitoring the amount of released force in different time intervals, as well as good cooperation with patients, are a requirement for successful orthodontic treatment. (Pithon 2016 & Singh 2012).

The application of intraoral elastics in orthodontics began in the 1890s. Various data can be found in the literature about the first beginnings of elastic bands in everyday practice. Most orthodontists of that time believe that Henry Baker was the first to use them, who introduced them as "Baker anchorage" in 1893, but another group believes that Calvin Case was the first orthodontist who used intraoral elastics as early as 1890. (Kardach 2019, Singh 2012, Dent 2022, Patel 2018, Sanaz 2019, Sauget 2011)

Two parameters define orthodontic bands: the diameter (3.2 mm, 4.8 mm, 6.4 mm, 8 mm, 9.5 mm, 13 mm, 16 mm and 19 mm) and the force they release (70.9 gr, 127.6 gr, 184.2 gr, 226.8 gr and 397 gr). In everyday orthodontic practice, intraoral elastics with a diameter of 4.8 mm are the most used and a force strength of 127.6 g. (Kanchana, P., Godfrey, K. (2000) determined that this type of intraoral elastics are more homogeneous and show less variation in the sample compared to the other dimensions of the elastics.

According to the material from which they are made, there are two types of orthodontic elastics: latex elastics made of natural rubber and latex-free elastics made of synthetic rubber, which is an artificial polymer and reproduces to a higher or lower degree the physical properties of natural rubber.

Natural latex is an isoprene polymer consisting mainly of heavy molecules and small amounts of proteins and fatty acids. Although natural latex is not allergenic, it has weaker mechanical properties that require reinforcement. Ammonia is an additive used to improve the mechanical properties of latex despite the fact that its addition produces allergens. Another strengthening process that also generates allergens is vulcanization which involves the addition of accelerators and antioxidants. According to the American Dental Association, approximately 0.12%–6% of the general population and 6.2% of dental health professionals are hypersensitive to latex. The effects of hypersensitivity vary from dermatitis to anaphylactic shock. (Alavi 2014, Ardani 2018, López 2012, Vieira 2013, Montenegro 2018 & Kersey 2003). As a result of the allergy caused by latex, the need for the production and commercialization of latex-free products has arisen. In the early 1990s, latex-free elastics for latex-allergic patients began to be synthesized.

Latex orthodontic elastics are widely used in orthodontics due to their low cost and high flexibility. The main characteristic of elastics is their elasticity, which is a property defined by the ability to return to its original dimension after undergoing significant deformation. Over time, the strength of the initially applied force decreases and thus the movement of the tooth may decrease or stop. (Alavi 2014, Ardani 2018, López 2012, Nitrini 2019, Eltahir 2017 & Ajami 2017). When the elasticity of the latex is loaded with a certain force beyond its limit, fatigue of the material begins in the weak points of the inner surface due to lack of homogeneity. Friction between molecular chains also causes dynamic fatigue of the material and strength degradation is more pronounced under unfavorable conditions, such as in the oral cavity. (Wang 2007, Leao Filho 2013, Fernandes 2011).

During orthodontic therapy, elastics lose their initial strength as a result of various physical and chemical factors that lead to a change in their structure. In the oral cavity, elastic bands are subject to constant forces. A significant decrease in their strength occurs during the first day of use and the greatest loss in the first hour of their application according to Kanchana, P., Godfrey, K. (2000). Diameter size affects force degradation, with smaller size elastics needing to be replaced more frequently to maintain intended force action as per the study of Patel, RA., Khonde, SK., Mehta, FN., Raval, KK. (2018).

After being placed in the oral cavity, the elastics lose part of their initial strength due to oral activities (chewing and talking) but also due to their exposure to environmental factors (saliva, food and drinks with different acidity and alkalinity, intraoral pH and temperature variations, enzymatic and microbial action, as well as the patient's dental hygiene). The normal stretching of the elastics during speaking and chewing (dynamic environment) is between 20 and 50 mm. Pithon 2016 & Wang 2007).

The rate of degradation of the elastic force consists of two curves: an initial rapid degradation of forces that occurs in the first 3-4 hours after stretching the material and a latent degradation, which follows this period. In the literature there is an empirical rule (rule of "3") which shows that elastics have 300% greater tensile strength in relation to their diameter. Ajami 2017 & Gioka 2006).

There are conflicting opinions in the literature about the mechanical properties of latex and non-latex elastics, especially regarding their initial strength and strength degradation. Castroflorio, T., Sedran, A., Spadaro, F., Rossini, G., Cugliari, G., Quinzi, V., Deregibus, A. (2022). Most studies have examined the strength loss of intraoral elastics in a static environment, and a small number of studies have examined the effects of this change in a dynamic environment. The results showed that cyclic testing (repeated stretching) caused a significantly greater loss of strength than static testing, and this difference occurred primarily in the early period of the stretch. Wang, T., Zhou, G., Tan, X., Dong, Y. (2007).

Strength tests of latex-free elastics compared to latex elastics in a dynamic environment showed a significant reduction in the strength of latex-free elastics by up to 50% in the first 24 hours, thus confirming the limitation of these elastics in maintaining constant force over a longer period of time. Notaroberto, DFC., Martins, M., Goldner, MTA., Mendes, AM., Quintão, CCA. (2018) Tests found no significant differences in strength loss between the two groups of elastics during static testing. Oliveira 2017 & Montenegro 2018).

In general, elastics show a greater loss of strength in a wet environment compared to a dry environment. Several studies have confirmed that saliva and bacteria can infiltrate the molecular structures of elastics, weakening the surfaces of the latex resulting in changes in color and tensile strength. It has also been proven that these elastics lose more strength at temperatures above 45°C due to the rigidity of the material. (Montenegro 2018 & Pilon 2018).

The pH of normal saliva at rest ranges from 5.6-7.6, depending on the diet. When consuming very acidic drinks, the pH of saliva is low, which affects the degradation of the strength of latex elastics. (Sauget 2011, Ajami 2017 & Dos

Santos 2012).
Since there are conflicting data in the literature on the mechanical properties of latex and non-latex elastics, the question arises whether elastics can provide the expected strength when under the influence of so many physical and chemical factors, and how they should be used to achieve successful orthodontic treatment?
The aim of this paper was to determine, through the analysis of data from the available literature, whether there is a relationship between the strength degradation of different types of orthodontic intraoral elastics and the material from which they are made, in different environments and in different time intervals.

2. MATERIAL AND METHOD

To realize the set goals, an electronic search of published studies on this issue was conducted through the PubMed and Google Scholar databases, using the following keywords and titles of medical topics: "intermaxillary elastics", "latex intraoral elastics", "latex-free intraoral elastics", "in-vitro studies" and "force degradation". Published studies in the last 25 years were analyzed, with the exception of a very small number of studies that are original and cited in all newer studies. The literature search was performed according to the PRISMA guidelines with the following main eligibility criteria: only studies published in English and studies conducted in human populations. Of particular interest were clinical studies, in vitro studies, prospective and retrospective studies, and systematic reviews and meta-analyses.

3. DISCUSSION

Several authors have examined the degree of deformation of different types of intermaxillary elastics, placed in different environments and at different time intervals, from different manufacturers. Nitrini et al. 2019, examining the degradation of the strength of intermaxillary elastics in different periods of time, concluded that they should be changed every 24 hours to achieve successful results of orthodontic therapy. In contrast, Kardach et al. 2019 suggest changing the elastics at 12 hour interval, at the same time stating that the artificial and wet environment have a negative effect on their characteristics, which contradicts the findings of LeaoFilho et al. 2013, who determined that the different chemical composition of drinks has no significant influence on the degradation of their strength. Several authors in their studies concluded that intraoral latex elastics have greater stability in the first 24 hours compared to non-latex elastics, which should be changed every 6-8 hours to achieve successful results. (Oliveira 2017, Patel 2018 & Sanaz 2019).
Castroflorio et al. 2022 compared the measured forces of orthodontic elastics used for the correction of class II malocclusion with the forces declared by the manufacturers, in dry and wet environments. The results showed that the smallest discrepancy between the tested and declared forces, at the average measured distance between the upper first premolar and the lower first molar, was observed in the elastics with dimensions of 4.8 mm and a force of 127.6 g. The higher strength elastics showed the lowest percentage of strength degradation over time. Evaluation of the strength degradation of latex elastics in vivo and in vitro in dry and wet environments was also investigated by Wang et al. 2007, which according to that study the degradation of the elastic force is different depending on the environment. The lowest strength loss was observed in the dry air environment. The most significant strength degradation occurred in the first half hour in both studied groups, and the reduction was greater in intermaxillary than intramaxillary traction.
Gioka et al. 2006 examining the strength degradation of latex elastics over a period of 24 hours determined a loss of the initial strength of the elastics of 25%, with the greatest loss occurring in the first 3-5 hours of extension of the elastics regardless of the dimension. , the manufacturer or their force. Similar findings were reached by Dubovská et al. 2023 who examined the values of the initial force of latex elastics with a diameter of 4.8 mm and a force of 127.6 g, from five different manufacturers and five different packages from different series. Strength degradation was measured after 2, 8, 24 and 48 hours of their extension. The results showed a strength loss of approximately 25% within 24 hours. The greatest degradation of strength occurred during the first two hours, while the degradation of strength in 24 hours ranged from 20% to 33% for all manufacturers.
Alavi et al. 2014 examined the strength degradation of latex-free elastics from three different manufacturers in a wet environment with artificial saliva over a 24-hour period. The results showed significant differences in strength loss between different manufacturers. In all samples, the strength loss was from 4-7.5% after one hour and from 19-38% after 24 hours. According to the initial force and the percentage of the degradation of the force, the authors suggest changing the latex-free elastics several times during the day in order to maintain the constancy of the force.
The difference between latex and non-latex elastics from the same manufacturer, with diameters of 3.18mm, 4.8mm, 6.35mm and 7.94mm placed in distilled water with a constant temperature of 37◦C and a time period of 72 hours, was also investigated by Vieira et al. 2013 . The results showed a higher initial strength of latex-free elastics but also a greater degradation of it compared to latex elastics, which showed more stable results during the time interval. The

same findings were reached by Montenegro-Moncayo et al. 2018, who, examining the strength of latex and non-latex elastics from the same manufacturer, placed in artificial saliva for 24 hours, determined a lower degradation of the strength of latex elastics compared to non-latex elastics (8.7% reduction in latex elastics and 9.3% reduction in non-latex elastics, in 24 hours). The greatest degradation of strength in both studied groups occurred in the first 6 hours after stretching the elastics.

Ardani et al. 2014 examined the strength degradation of latex and non-latex elastics (American Orthodontics (AO) and Ortho Technology (OT)) with a diameter of 3.18 mm and 4.8 mm placed in artificial saliva (pH 6.7) over a period of 48 hours. . The results showed significant differences in strength degradation between latex and non-latex elastics at 24 hours, and a non-significant difference at 24-48 hours. In contrast to previous findings, Ardani et al. 2014 found greater strength degradation in latex elsstics compared to non-latex elastics. The analysis of the chemical structure of latex-free elastics from both manufacturers and latex elastics from OT showed a higher presence of carbon (C), while a higher presence of aluminum (Al) was observed in latex elastics from AO.

Ajami et al. 2017 investigated the correlation between the fluctuation of salivary pH and the strength degradation of latex elastics manufactured by the manufacturer 3-M Unitek at different time periods. The results showed no significant differences between the fluctuation of pH and the degradation of the elastic strength in the different time periods, with the exception of the 36-hour interval.

The same findings were reached by Sauget et al. 2011 and Dos Santos et al. 2012 who in their studies examined the influence of different pH values of artificial saliva on the strength degradation of latex and non-latex elastics in different time periods. The results showed no significant correlation between the pH value and the strength of the elastics. The authors concluded that the time interval is the most important factor in the degradation of the force in intermaxillary elastics.

4. CONCLUSION

In the world literature, there are various data on the influence of various physical and chemical factors on the degradation of the strength of intermaxillary elastics. First of all, these are: the materials from which they are made, the time period and the environment in which they are placed, as well as their diameter and strength. All conducted studies indicate a positive correlation between the degradation of the strength of different types of orthodontic intraoral elastics from different manufacturers and the material from which they are made, different environments and time intervals. The analysis of the data from the available literature indicated that the most important parameter in the loss of strength is the elastic stretching time.

Before starting orthodontic treatment, orthodontists must know the optimal time for changing the intermaxillary elastics during orthodontic therapy, which type of elastics have more stability, as well as which factors affect the degradation of the force, in order to better treat patients with orthodontic malocclusions.

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