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Original Article

In Vitro Comparative Analysis of the Tensile Strength of Elastomeric Chains Disinfected with Quaternary Ammonium and Alcohol

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Abstract - *The study compares in vitro the tensile strength of elastomeric chains (EGRT) disinfected with quaternary ammonium and 70% alcohol. It focuses on disinfection protocols in orthodontics, whose vulnerability is due to cross-infections. The research is relevant due to the COVID-19 pandemic, which resulted in the search for new disinfection protocols. The WBRT was disinfected with two agents: quaternary ammonium and 70% alcohol. A universal testing machine was used to measure the tensile force and compare the results to determine the impact of each disinfectant agent. The results indicate that quaternary ammonium and 70% alcohol have different effects on the mechanical properties of Elastomeric Chains (ECs). 70% alcohol tends to degrade mechanical properties more than quaternary ammonium. We can conclude that quaternary ammonium disinfection is preferable to maintain the mechanical properties of elastomeric chains in orthodontics. This study provides valuable information for clinical practice, helping professionals to choose disinfection methods that do not compromise the efficacy of orthodontic treatment. Due to the risks associated with other diseases, such as COVID-19, it is crucial to adopt effective disinfection protocols that do not compromise the mechanical properties of the materials used.*

Keywords - *Comparison, Disinfection, Orthodontist, Elastomeric chains, Alcohol, Quaternary ammonium.*

1. Introduction

Dental practice is an activity that is very vulnerable to cross-infections, and in terms of dental specialities, orthodontics stands out among those with the greatest number of predisposing factors[1],[2]. Orthodontics is characterized by the number of patients and the multiplicity of instruments for transmitting diseases (materials, instruments, operators' hands, etc.), thus exposing clinicians, assistants and patients to serious risks of infection[3]. Given the increasing incidence of Covid 19 infections, sterilization and disinfection measures in dentistry have increased considerably to prevent the spread of the virus and possible cross-contamination[4]. To inactivate COVID-19 and other viruses or bacteria, there are some recommended substances such as glutaraldehyde (0.5 – 2.5%), formaldehyde (0.7 – 1%), povidone iodine (0.23 – 7.5%), sodium hypochlorite (0.5 -1%), hydrogen peroxide (0.5%), peracetic acid (0.2%), quaternary ammonium compounds and alcohol 70% [5], [6]. Biomechanics in orthodontics uses various force systems that promote tooth movement in the mouth. Among them are elastomeric chains, whose use is part of the clinical routine of orthodontists and are used for numerous procedures such as corrections of dental rotations, consolidation of spaces, closure of spaces through retractions or traction of teeth and correction of the midline if it has suffered a deviation[7], [8].

The stretching process of ECs that causes changes in their mechanical properties is of interest because these materials remain in the oral cavity for a relatively long time and must exert a clinically adequate force during this period[9]. The correct choice of orthodontic elastics and careful control of the force released at different time intervals are essential for the safe and satisfactory performance of orthodontic treatment. Their elastic properties, ease of application, and cost-effectiveness make them important in orthodontic treatment. However, they degrade rapidly in the oral cavity and may present substantial alterations in their physical and mechanical properties[10]. Many disinfecting agents have been employed in the dental office with respect to orthodontic elastomeric chains. However, few studies have investigated the effect of quaternary ammonium washing and disinfection on the mechanical properties of orthodontic ECs.

The research objective of this study is to evaluate the WBRT that is altered with disinfection, depending on the material used for the quaternary ammonium or 70% alcohol process. It is important to study and know the behavior of the elastomeric chains for the safe and satisfactory performance of orthodontic treatment since they remain in the oral cavity, a very complex environment, for a relatively long time, and their properties can be affected by saliva, pH changes, masticatory forces, if it is pre-stretched, mechanical brushing, exposure to different foods, and when they are disinfected before placement. Such an understanding will help the professional to plan appropriate intervals between appointments to activate these elastomeric chains and thus understand their behavior to obtain adequate results.

This research is highly relevant since, given the situation due to the increase in Covid 19 infections, it led to intensify the disinfection protocols of orthodontic instruments and materials, including elastomeric chains, which, Due to its presentation in a roll and not in individual packages, it leads to the development of cross-infections, which will oblige the professional to disinfect these chains before their use inside the oral cavity, either with quaternary ammonium and/or 70% alcohol, due to their easy access and low cost. This research, by comparing the resistance of elastomeric chains disinfected with quaternary ammonium and 70% alcohol, will allow the clinician to know the most appropriate way to disinfect the materials used within the oral cavity to avoid cross-infections by HIV, Hepatitis B and Covid 19 infections, given their growing incidence and high rate of infections and without harming the treatment.

2. Literature Review

Berni Osorio et al. (2022) [11], in their 2022 research, analyzed the use of different disinfectants on mechanical properties in EC orthodontic procedures. This study classified 120 elastomeric chains into six groups using the disinfection method. In the first group, which was the control group, the elastomeric chains were not immersed in any solution; in the second group, the chains were submerged in 2% glutaraldehyde; in the third group, immersed in a 70% alcohol solution; in the fourth group, the chains washed in an ultrasonic washing machine (LU) in a 0.5% solution of enzymatic detergent; in the fifth group the LU method was performed followed by immersion in 2% glutaraldehyde and in the sixth group the LU method was performed followed by immersion in 70% alcohol. Once the asepsis was completed, the tensile strength was tested in a universal machine, finding statistically significant results ($P < .05$) using unidirectional ANNOVA and T-Dunett tests. Disinfection with 2% glutaraldehyde showed no significant alteration in the mechanical properties of the elastomeric chains. On the contrary, 70% alcohol showed negative changes in all mechanical properties of elastomers, in addition to washing in LU with EC-affected enzymatic detergent at the maximum applicable strength. It was concluded that 2% glutaraldehyde but not 70% alcohol can be used to disinfect elastomeric chains since it alters the mechanical properties of elastomeric chains.

Barati et al. (2021) [12] compare the effects of disinfection of peracetic acid and glutaraldehyde on the tensile strength of ECs. Thirty elastomeric chains were evaluated and disinfected in three groups: 10 control chains without disinfectant, 10 chains with 0.25% peracetic acid for half an hour, and 10 chains with 2% glutaraldehyde for half an hour, and the strands were washed with distilled water for 1 minute. 12 mm long chains were placed in a Universal Testing Machine and stretched at a 20 mm x min speed until breakage. The results were analyzed using the ANOVA test with Tukey’s post hoc test: significance of $p<0.05$. Glutaraldehyde and peracetic acid reduced tensile strength and elastic chain elongation compared to the control group, which was not clinically significant.

Silva Chaves-Filho et al. (2021)[13] The purpose of this study was to evaluate the in vitro loss of resistance of different ECs after different times (initial, 10 min, 1 day, 28 days and after mechanical brushing). 100 segments of orthodontic elastic chains were divided into 5 groups (control, GAC, G&H Orthodontic and Abzil and Morelli). Each 15 mm long segment was stretched to 20 mm with an Instron measuring the strength in gf. The samples were then stretched on an acrylic template at 20 mm intervals and immersed in deionized water at 37 °C for 10 minutes, after which the strength (gf) was measured again. Five remnant strength test measurements were performed for each time interval: initial, 10 minutes, 1 day, 28 days, and mechanical brushing. In the last interval, the acrylic plates with the samples were adapted to the mechanical planers.

The elastomeric chains were subjected to mechanical brushing by re-measuring the force (gf). The strength (gf) was subjected to mixed model ANOVA and post-hoc Sidak test ($\alpha=0.05$). As a result, there was a drop in strength for all types of elastomeric orthodontic chains at day 1, 28 days and after mechanical brushing ($p<0.05$) that was statistically significant. Ebrahiminik et al. (2021)[14] I study the effects of disinfectants such as povidone-iodine (PVP-I), chlorhexidine and hydrogen peroxide on the mechanical properties of ECs in orthodontic processes. 130 elastomeric ligations were studied in vitro in three test groups and two control groups for 28 days. All samples were stored in artificial saliva except those in the control group and kept dry in a dark environment.

The elastomeric ligations were immersed in a solution of hydrogen peroxide (5%), PVP-I (1%) and a chlorhexidine (0.02%) for one minute daily at three time intervals: day, 7 days and 28 days. The maximum strength of the chains was then tested on a universal testing machine (CN 1174, Germany). The ANOVA test verified that the WBRT in the three test groups decreased after 28 days. (p-value < 0.05), but the results were not statistically significant. In conclusion, PVP-I has the same effect on elastomeric ligatures as artificial saliva, chlorhexidine, and hydrogen peroxide, and PVP-I can be used safely in the COVID-19 era.

Andhare et al. (2021)[15] evaluate and compare the reduction in strength of orthodontic elastomeric modules in vivo. Fifty-three articles were selected from the Cochrane, MEDLINE and PubMed databases, of which forty-four studies were in vitro and the rest in vivo. A detailed protocol that conforms to the PRISMA 2020 guidelines was developed and followed, applying the appropriate statistical analysis. When assessing the drop in mean strength in the in vivo setting, it was found that 41.9% decreased at 24 hours, 42.6% at week, 46.8% at 2 weeks, and 55.0% at 3 weeks. Similarly, the drop in strength in in vitro studies was 38.9% at 24 hours, 42.1% at week, 44.6% at 2 weeks, and 51.1% at 3 weeks. In conclusion, there was a greater drop in strength in the in vivo studies than in vitro studies, and the maximum drop in strength occurred during the first days, with an approximate decrease of 50% in 3 weeks.

Kassir et al. (2020)[16] compare the strength degradation of various gray, transparent, closed and open chains and 4 commercial brands: American Orthodontic, Dentsply, Ormco and Rocky Mountain. A universal testing machine was used to measure the strength of the chains that were elongated to 25 mm at 0 hours and then stored in artificial saliva at 24 hours, 1 week, 2 weeks, 3 weeks and 4 weeks.

Tukey’s significant difference test was performed. This study revealed that elastomeric chains can be clinically effective even after 4 weeks of elongation at a strength between 100 and 300 g, which is optimal for physiological tooth movement.

Ferraz et al. (2020)[17] aimed to evaluate the effect of cigarette smoke on the tensile strength of the EC. Four different elastics from two different manufacturers were evaluated: Maximum Power Chain Pearl (OTP) (OrtoTecnology); Maximum Power Chain Pearl Tone Blue (OTPB) (OrthoTechnology); Grey Orthodontic Elastic Chain (MG)(Morelli); Orthodontics Crystal Elastic Chain (MC) (Morelli). The elastic segments were exposed to tobacco smoke and then stretched for 8 minutes, 2 times a day, with an interval of 12 hours.

Elastic tension was assessed at baseline, at 7, 14 and 21 days.” It was evidenced that all elastics presented a statistically significant progressive reduction in tension. The OTP and OTPB elastics presented higher initial tension than the MG and MC elastics. As a result, exposure to smoke promoted a drop in strength that ranged from 7% (OTP) to 12% (OTPB). Concluding that experimental exposure to tobacco smoke contributed to the degradation of elastomeric chain strength over 21 days.

Mattos et al. (2019)[18] evaluated the elastic deformation of 14 commercial brands subjected to different disinfection means stretched for 7, 14, 21 and 28 days. The elastics were cut and measured with a digital pachymeter, immersed in 70% alcohol, 0.2% peracetic acid, and in an autoclave (121°C / 1 atm / 30 minutes). 20 samples of each commercial brand were used, of which 5 were placed directly in the control template, 5 were immersed in 70% alcohol, another 5 in 0.2% peracetic acid, and 5 in an autoclave (121°C / 1 atm / 30 minutes). The samples remained stretched on the insole in artificial saliva at 37°C, and then the elastics were removed to be measured.

As a result, it was evident that all elastics presented a progressive reduction in tension during the period evaluated, and there was a statistically significant difference between brands, disinfection means and times, as well as between possible interactions between groups. It was concluded that plastic deformation varies according to the brand, time and the disinfection medium used. Also, the method that least affected the properties of elastics was the autoclave cycle, and the one that was most affected was peracetic acid, without considering the factors of time and brand. In addition, the TP Orthodontic brand had the lowest percentage of plastic deformation, and the largest percentage was the Morelli brand.

Torres et al. (2019) [19] analyze the strength degradation behavior of the ECs of different brands (TP Orthodontic®, American Orthodontic®, TD Orthodontic®, Ah Kim Pech® M). For the in vitro study, 50 segments of each elastic chain mark were used, divided into four groups and evaluated at 7, 14, 21 and 28 days, stretched and remained constant until breakage. An INSTRON 3365 universal testing machine was used for degradation calculation. As a result, among the brands studied, TD Orthodontic® shows the highest maximum load value of 37.13 N. being the elastomeric chain studied with the highest fracture resistance, compared to that of American Orthodontic®, which evidenced the lowest maximum load of the entire sample, 17.78 N. It was concluded that the degradation of the strength of the elastomeric chain depends on the trademark used. TD Orthodontic® recorded the highest values, proving to be the most efficient elastomeric chain under the tension test.

Lucindo et al. (2019)[20] In vitro experiment to evaluate the degradation of the forces generated by aesthetic ECs in three different sizes: short, medium and long. For the evaluation of resistance degradation, 90 EC segments were used, which were divided into 9 groups (n=10), being: short Morelli elastomer, medium Morelli, long Morelli, short orthometric, medium orthometric, long orthometric, short American Orthodontic, medium American Orthodontic and long American Orthodontic”. Acrylic plates with pins were used to stretch the elastomeric chains. Initially, a force of 150 grams was measured with a blood pressure monitor. They were then stretched to 50% of their original length, measured on a Universal Instron 4411 machine and brought to the seatpost on the dashboard. The signal was immersed in a plastic container with artificial saliva at 37 °C and removed after 21 days for measurement. The mixed model methodology for repeated measurements over time and the Tukey-Kramer test were applied. The degradation of forces was analyzed using the Analysis of Variance (ANOVA) "2 factors" and Tukey's test. As a result, it was evidenced that all ECs experienced a statistically significant decrease in strength ($p<0.05$). In conclusion, all three brands studied significantly reduced the amount of force released, with the American Orthodontic elastomeric chain showing the greatest strength degradation.

Elastomeric chains are a common component in orthodontics that apply constant forces to teeth. However, exposure to saliva, bacteria, and cleaning agents can affect its mechanical properties, such as tensile strength and elongation. This abstract analyses several studies investigating the effect of disinfection and mechanical brushing on the mechanical properties of elastomeric chains. From this analysis, we can observe that:

- 2% glutaraldehyde is a safe option for the disinfection of elastomeric chains, as it does not significantly affect their mechanical properties.
- 70% alcohol should be avoided for the disinfection of elastomeric chains, as it can have a negative effect on their mechanical properties.
- Mechanical brushing can also reduce the tensile strength of elastomeric chains.

These studies have been conducted in vitro, so the results may not directly apply to clinical practice. More research is needed to evaluate the effect of mechanical disinfection and brushing on the mechanical properties of elastomeric chains in the long term. This has been the study's starting point.

3. Basic Concepts

Natural rubber, the first known elastomer, is obtained from a variety of plants, mainly from the so-called rubber plant (Hevea brasiliensis)[20], [21], initially consisting of 25-40% rubber hydrocarbon (cis 1,4 polysoprenol) and in small quantities protein material and fatty acids. These elastomers initially had many limitations, which led Charles Goodyear in 1839 to develop vulcanization. This is an irreversible process of heating raw rubber with sulfur to make it harder and more resistant to cold to try to eliminate the defects of these materials and improve their physical properties.

Linking it between chains through the formation of covalent cross-links[21], [22]. Synthetic rubber polymers have been created from petrochemicals in the 20s with weak molecular attraction. This is created based on primary and secondary bonds that have a unit (NH)-(C=O)-O-(7). The main component for manufacturing elastomeric chains is polyurethane, which was introduced in the 1930s. Polyurethanes contain urethane bonds that are produced by polyols and disocyanates[7], [23]) and are called viscoelastic materials because they have characteristics of elastic and viscous materials[22]. As an elastic material, it can return to its original shape. However, as a viscous material, it flows under the action of an external force and does not return to its original size[22]. EC was introduced into the dental industry in the 1960s and became a staple of many orthodontic practices. Baker, Case and Angle were the first to propose the use of natural rubber rubber in orthodontics[15], [23], [24].

Elastomeric chains are amorphous polymers formed primarily of polyurethane. Its chemical composition varies from manufacturer to manufacturer and is kept secret for commercial reasons [24]. We will classify them into 2 groups that differ mainly in origin: latex elastomer and synthetic elastomer. According to their composition, there are two elastomeric chains: the first generation is generally made with thermoplastic polyurethane, and the second is made with thermoset polyurethane[25]. Thermoplastic polymers, also called hybrids, combine thermoplastic technology with elastomer properties. They have a simple molecular structure linear or slightly branched polymers. They offer good elasticity at room temperature, but with heat, they lose their properties by deforming. They are not rigid enough and cannot maintain their strength over time. These limitations allowed the development of new chains that offer greater performance for orthodontic treatment, the second-generation elastomeric chains. These have a more rigid molecular structure and are made up of copolymers and highly branched polymers that are closely linked to each other by strong covalent bonds, which explains their greater resistance to traction and high temperatures[24], [25].

Polymers are composed of primary and secondary bonds. Primarily, polymers have a spiral pattern, but when subjected to forces, they deform and arrange in a linear structure with cross-links at certain sites along the chains. Secondary bonds change from a spiral model to a linear one, but due to the presence of their cross-links, they recover their initial structure[10]. Orthodontic elastomeric chains are presented as a joined roll, sectioned according to the number of links desired for each clinical situation[4], [16]. They have various presentations according to their thickness, size and distribution: open, closed, short, medium, and long sections.

According to the distance between links, the chains are divided into 3 types[24]:

- Continuous or closed chain: The link distance is 3 mm.
- Short chain: The interlink distance of this chain is 3.5 mm.
- Long chain: The link distance is 4 mm.

One of the main characteristics of elastomeric chains is elasticity[11][17]. This elastic capacity of chains has limits, and these extremely elastic materials can cease to be so, suffering a phenomenon called deformation. Elastic deformation exists when the body returns to its original state by removing the stimulus [26], and when the force applied is higher than the elastic limit of the material, plastic deformation occurs, causing permanent deformation [22].

In vitro clinical studies have shown that elastomeric materials are permanently stretched. Strength degradation remains the main concern of orthodontists as optimal and continuous strength is mandatory to achieve tooth movement [9, 17]. The force generated by elastics on a tooth or teeth depends on the magnitude, direction, length, site of application, distribution through the periodontal ligament, the contour of the root, the alveolar process, the health of the tooth and above all, the cooperation of the patient [22]. This strength differs from tooth to tooth depending on the morphology, number of roots, bone level, and types of teeth. Appliances are used that perform specific movements through the bone to achieve a precise and adequate biological and mechanical response in orthodontic processes. For this result, mechanical attachments such as CE, brackets, ligation, and arches are used, being also decisive in professional practice the knowledge about the properties, composition, forces and effects exerted by each of the materials, which is visualized in a certain time of stability and the good orthodontic process [12, 13]. The advantages provided by elastomeric chains are considered practical, effective, easy to apply by the clinician, comfortable, and do not require the collaboration of the patient [15, 16, 19, 20, 22] and are less traumatic [17, 20]. They are also available in various colors, resulting in patient motivation, for aesthetic reasons, particularly in young patients.

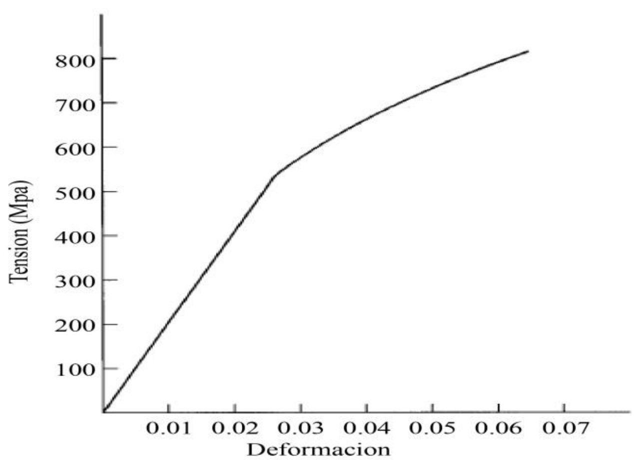

Fig. 1 Graph stress/strain

Other materials serve the same functions as chain orthodontic elastomeric chains, such as closed coil springs, open coil springs, retraction springs, locking loop arches, and magnets [27]. Coil springs are difficult to clean, while retraction springs and locking arches can irritate the patient's gums and mucosa. Magnets are bulky, expensive, and difficult to clean [20, 24]. Among these elastics' disadvantages is their mechanical properties, which are altered with time and temperature[18]. When exposed to the oral environment, they absorb saliva and water, breaking the internal chemical bonds that cause permanent deformation.

They are also sensitive to free radicals, such as ozone and ultraviolet light. When exposed to these radicals, the flexibility of the polymer is reduced, so some manufacturers have added antioxidants and anti-ionizers to delay these effects [18]. Elastomeric chains do not possess continuous strength over time. Several studies have shown that the degradation of the initial strength of elastomeric chains is greatest on the first day and continues regularly at a much slower rate, losing between 50 and 75% of strength after 4 weeks [9]. According to the WHO, "biosafety is a strategic and integrated approach to analyzing and managing risks relevant to human, animal and plant life and health and associated environmental risks". In the 1970s, the concept of biosafety was introduced at the Asilomar meeting in California, where the social impact of genetic engineering began to be discussed. Since then, the term biosecurity has evolved over the years and is now considered a set of measures to prevent, reduce or eliminate risks from different activities [1]. Disinfection is the process by which microorganisms of vegetative forms are eliminated in inanimate objects without ensuring the elimination of bacterial spores [2, 6]. Sterilization is a process that eliminates all microorganisms (bacterial spores).

According to Spaulding, orthodontic instruments can be divided into three groups:

- Critical: instruments that penetrate the oral mucosa, such as bands and mini-screw kit. It is necessary to sterilize.
- Semi-critical: instruments that touch the mucosa, such as intraoral mirrors and mathius forceps. High-level sterilization or disinfection is required.
- Less critical: those not meeting the mucosa, positioners, and forming pliers. Intermediate-level cleaning and disinfection is indicated [1, 2, 6].

Dental procedures are also given an equivalent classification:

- Non-critical: these are procedures in which there is no presence of organic secretions, blood or pus.
- Semi-critical: when there is organic secretion (saliva) but without loss of continuity of skin and mucous membranes (orthodontic procedures).
- Critical: when there is contamination by blood, pus, or loss of tissue continuity [6].

Orthodontists generally do not perform extensive surgical procedures; however, patients may carry germs that can transmit and infect other patients or healthcare personnel.

Using appropriate sterilization techniques in daily clinical practice is important for ethical, professional and legal reasons[1], [6]. In this way, the autoclave should be the first option, as it is the only form of sterilization. However, some materials can suffer damage to their mechanical properties[5]. In addition, when working with semi-critical material, various chemicals can be used to perform disinfection[5], such as glutaraldehyde (0.5 – 2.5%), peracetic acid (0.25%), formaldehyde (0.7 – 1%), povidone-iodine (0.23 – 7.5%), sodium hypochlorite (0.5-1%), hydrogen peroxide (0.5%), quaternary ammonium 0.4% to 0.5%, alcohol 70% ([3], [5], [11], [12], [14], [18]).

3.1. Cross-Infections

The oral cavity has the highest concentration of microorganisms, making the clinical environment more susceptible to exposure to biological risks. It is estimated that a drop of saliva can contain up to 600,000 bacteria[2]. Research shows that countless pathogenic microorganisms are present in dental instruments, including hepatitis B, HIV, hepatitis delta, herpes, and influenza, in addition to the tuberculosis bacillus[1]. Cross-infection is the transmission of infectious agents between patients and health personnel through direct contact. It occurs when microorganisms travel through any of these routes to nearby instruments, clothing or furniture. Dental procedures, instrumentation and material handling, require certain maneuvers for infection control. For an infection to be transmitted, it will depend on four factors: the sources of infection (patient/operator), the means of transmission (blood, saliva), route of transmission (inoculation: hepatitis virus, herpes simplex, HIV, SARS COV-2. inhalation: chickenpox virus, influenza, tuberculosis, etc.). and individual susceptibility (genetics, disease, nutritional status, medication, etc.).

3.2. Covid 19 Infections

COVID-19 stands for Coronavirus Disease 2019, a name given by the World Health Organization (WHO). It is a new disease caused by a member of the Coronaviridae family. SARS-CoV 2. is a beta-coronavirus with a positive-sense, unsegmented RNA genome, high mutation and recombination rates, and a protein coat or envelope of fat molecules[29], [30]. Beta-coronaviruses are capable of causing a severe infection of the respiratory tract. Two types of coronaviruses represent them: MERS-CoV (Middle East Respiratory Syndrome) and SARS-CoV (Severe Acute Respiratory Syndrome)[4]. SARS-CoV-2 uses the angiotensin-converting enzyme, a glycoprotein located in the endothelium of the pulmonary capillaries, as a cell receptor for human infection.

The transmission of this virus is by close contact through respiratory droplets when sneezing, coughing or talking (30) SARS-CoV-2 has been characterized by causing respiratory symptoms, cough, fever and in some cases anosmia and dysgeusia, in addition to gastrointestinal problems, muscle aches, chills and fever[31], [32]. Dental procedures have a high risk of COVID-19 infection due to direct contact with the care team and the patient[33]. In addition, frequent contamination with bodily fluids such as blood and saliva and the continued use of high-speed rotary instruments increases the risk of transmission [4].

3.3. Methods of Disinfection of Elastomeric Chains

Disinfectants are chemicals designed to eliminate or slow the growth of harmful microorganisms in their active stage and are applied to skin, objects, and surfaces to prevent and fight infection. Their effectiveness varies; they can be bactericidal, virucidal, fungicidal or sporicidal. There are various classes of disinfectants, such as detergents, acids, oxidizing agents, alcohols, alkalis, aldehydes, biguanides, halogens, phenols, and quaternary ammonium compounds[28], [29], [34]. Elastomeric chains are cold sterilized because they are not heat resistant. However, sterilization can be performed in an autoclave at 124 degrees without leading to permanent deformations[2]. The FDA recognizes Glutaraldehyde as a high-level disinfectant agent. It is also used for the disinfection of chains. It acts in the presence of organic matter as a disinfectant in a time of 30 min or a sterilizer in 10 hours. It can be used at 2% [11], [12] for 30 minutes or 5% for 10 minutes, but frequent disinfection can cause alterations in its polyurethane molecules, destroying the cross-links in the polyurethane molecules[9], [11], [12], [35].

Decreasing its tensile strength and maximum elongation to the breaking point[2] and its toxicity can cause irritation and burns to the skin and mucous membranes[5]. Another disinfectant agent is peracetic acid, formed by hydrogen peroxide and acetic acid. It also acts in the presence of organic matter against bacteria, spores, viruses and fungi. Compared to glutaraldehyde, it is a non-toxic and non-allergic product; its disinfection time is 15 minutes, and sterilization is 30 minutes [18].

3.4. Quaternary Ammonium

Quaternary Ammonium Compounds (QACs), since their introduction in the 1940s, are some of the most widely used broad-spectrum antimicrobial agents in industrial, domestic and hospital settings[36], [37]. QACs were first introduced between 1915 and 1916 as derivatives of hexamethylenetetramine, and in 1935, their wider use began with the development of benzalkyl dimethylammonium chloride (ADBAC or benzalkonium chloride or BAC)[36]. QACs are surfactant compounds of amphiphilic nature, and they have an antimicrobial mechanism of action like that of detergents, which means that they target the membrane of the bacteria and the lipid layer of the enveloped virus, causing its destabilization and permeabilization.

QACs have a broad spectrum of antibacterial activity. Although they demonstrate greater activity against Gram-positive bacteria, they also have a virucidal effect (only against lipophilic bacteria) and are a powerful antifungal agent in very low concentrations. It is neither sporicidal nor microbactericidal nor has action on hydrophilic viruses[38]. Chemically, it comprises four aliphatic or aromatic radicals attached to a central nitrogen atom [38], [39]. The effectiveness of QACs is affected by their carbon chains. It is important to note here that QACs with twin alkyl chains are more efficient than single-chain ones, and the single-alkyl chain has between 12 and 16 carbon molecules and has a stronger activity than that of another number of carbons in the chain[40]. The most used QACs in hospital units are Alkyl-Dimethyl-Benzyl-Ammonium Chloride (ADBAC), Alkyl-Didecyldimethyl-Ammonium Chloride (DDAC), and Dialkyl-Dimethyl-Ammonium Chloride. Didecyldimethyl-ammonium chloride (DDAC) comprises 2 alkyl chains, each consisting of 10 (C10, didecyl) carbon atoms. They also include mixtures comprising C8 (octyl), C10, and C12 (dodecyl) chains. It is an antimicrobial that acts on bacterial membranes and shows bacteriostatic and bactericidal activity depending on its concentration [40]. Ammonium chloride is a quaternary ammonium compound with antiviral activity against the coronavirus and has a mechanism of action, such as raising endocyte and lysosomal pH [39]. QACs work by deactivating the protective layer of lipids that envelop SARS CoV-2 viruses and can deactivate the virus in just a few minutes. Quaternary ammonium compounds are widely recommended for killing viruses due to their effectiveness in provoking the lysis of the phospholipid bilayer present in the cell membrane and viral envelope [38]. Fifth-generation QAC, at a concentration of 10 to 50 mg per liter, results in higher microbicide performance, especially in harsh environmental conditions, and is also non-corrosive to metals or clothing. Even at concentrations of 1:20,000 and 1:50,000 w/v, they can disinfect dental root canals without causing periapical inflammation Table 1.

Table 1. Chemical components of quaternary ammoniums according to their generations

Quaternary Ammonium Generation of Chemical Components		Acronyms
First	Alkyldimethylbenzylammonium chloride (benzalkonium chloride)	ADBAC
Second	Alkyldimethylbenzylbenzylammonium chloride	ADEBAC
Third	Alkyldimethylbenzylammonium chloride + Alkyldimethyl benzylbenzammonium chloride	ADBAC+ADEBAC
Room	Didecyl dimethyl ammonium chloride	DDAC
Fifth	Alkyldimethylbenzyl ammonium chloride or alkyldimethyl Ethyl benzyl ammonium chloride + didecyl dimethyl ammonium chloride	(ADBAC or ADBAC)+ DDAC

Fountain [38]

First-generation QACs, such as benzalkonium chloride used for hand disinfection, are not indicated against SARS-CoV2 (40). However, in fifth-generation QACs, when didecyl dimethyl ammonium chloride was added, efficacy against Gram-positive and Gram-negative bacteria, as well as against the influenza virus, was increased. Among the QACs for sale is Zeta 3 Foam. It has a ready-to-use concentration and a wide biocidal field of action. 100 g of Zeta 3 Foam contains 0.315 g of dimethyl-didecyl-ammonium chloride, 0.075 g of al-yl-benzyl-dimethyl ammonium chloride, nonionic surfactants, additives, adjuvants and water. A spectrum of action: Bactericidal (S. aureus, P. aeruginosa, E. hirae), fungicidal (C. albicans), tuberculocidal (M. terrae) in 5 minutes and virucidal (poliovirus, adenovirus, norovirus and parvovirus, including HIV, HBV and HCV) in 1 minute.

3.5. Alcohol 70%

Alcohol is an intermediate-level disinfectant used as an antiseptic on surfaces and instruments, as well as on the skin. The effect of alcohol is the denaturation of proteins and the dissolution of fats. Not effective in the presence of organic matter[6]. Alcohol, mixed with water, alters the structure of proteins essential for the life of microorganisms [5], making it an effective killer of bacteria, fungi and viruses in their active growth phase. However, it is ineffective against spores [3], which are forms of resistance of some microorganisms. Its ability to kill bacteria decreases when its concentration is less than 50%, ideal for 60% to 90%. 75% isopropyl alcohol effectively disinfects hands against COVID-19, but it is not recommended for use on surfaces. For the latter, it is suggested that isopropyl alcohol be used with a different concentration. It is important to remember that frequent use of alcohol can damage certain materials. In addition, alcohol only provides low- or intermediate-level disinfection, so it is recommended only for disinfecting semi-critical and non-critical materials [29], [35]. Alcohol is the most commonly used disinfectant because it is accessible [18]. Unfortunately, it is the least effective because it has a bacteriostatic effect that is more bacteriostatic than bactericidal against vegetative forms, in addition to evaporating quickly. It is very short-acting. These characteristics mean that alcohol is not accepted by the ADA as a material for the disinfection of instruments [6].

3.6. Saliva Artificial

The salivary glands produce natural saliva as a complex secretion. Its production occurs in the major (93%) and minor (7%) salivary glands. 99.5% of saliva is made up of water, as well as minerals, electrolytes, hormones, enzymes, immunoglobulins, cytokines and other compounds that form a complex structure [10]. Its pH is 6.0 - 7.0. Saliva has enzymes such as esterases, catalases and oxidases, as well as proteolytic enzymes such as proteinase and carbonic anhydrase [27]. Mucins are the largest molecules in saliva. They are responsible for preserving, covering and lubricating oral tissues and are also involved in forming the food bolus. They can also relate to bacteria, fungi and viruses [41]. Smaller particles promote mineralization, cushioning, and oral lubrication. When interacting with smaller particles, mucins have properties such as creating a protective film and a film that allows the agglomeration of microorganisms [42]. Artificial saliva complements natural saliva, but it is difficult to imitate its physical and chemical composition as it varies constantly [10]. Artificial saliva is a saliva substitute that also contains $MgCl_2$, NaCl and cellulosic materials [9]. There is no globally accepted composition of artificial saliva. In Csek's study, the artificial saliva was composed of one liter of distilled water, 0.9g of calcium chloride dihydrate, 0.69g of dehydrated sodium dihydrogen phosphate, 0.4g of potassium chloride, 0.4g of sodium chloride, 0.005g of sodium sulfide nanohydrate and 1g of urea [27]. Others in their composition have potassium chloride 0.6 g, potassium dihydrogen phosphate 0.17 g, magnesium chloride 0.025 g, calcium chloride 0.148 g, carboxymethylcellulose 5 g, sorbitol 15 g and purified water [10].

4. Materials and Methods

The research method used in this study will be Deductive, with a quantitative approach. This research is applied with a research design that is experimental on the longitudinal type.

Population, sample and sampling

Population: Not included as it is an experimental project.

Inclusion criteria: Closed-section elastomeric chains

Grey chains

2nd generation

Properly packaged, without failure in manufacture and with an appropriate expiration date.

RMO, GC and AO Brands

4.1. Sampling

4.1.1. Sampling Type: Probabilistic

A simple random sampling was carried out with 90 segments of 21mm each of 2nd generation closed-section elastomeric chains, gray color of the GC (GC Orthodontics), AO (American Orthodontics) and RMO (Rocky Mountain) brands, which will be divided into 9 groups; control group, GC (group 1), AO (group 2) and RMO (group 3) elastomeric chains immersed in artificial saliva for 10 min; then GC elastomeric chains (group 4), AO (group 5) and RMO (group 6), immersed in quaternary ammonium for 10 min and elastomeric chains GC (group 7), AO (group 8) and RMO (group 9), immersed in alcohol for 10 min. Sample size (n)= 10.

4.2. Operational Definition

Tensile strength is the maximum tensile stress supported by elastomeric chains until fracture or plastic deformation [11]. Elastomeric chains: These amorphous polymers formed from polyurethane are used in orthodontics to move teeth. They are found in different colors; For the study, only gray [14]. Immersion solutions: Substances in which elastomeric chains will be immersed [7].

4.3. Data Collection Techniques and Instruments

4.3.1. Technique: Observational

Description of instruments: 90 samples of elastomeric chains were needed, five links of each, 30 of the RMO brand, 30 of the GC brands and 30 of the AO brand, which will be immersed for 10 min in artificial saliva, 10 min in quaternary ammonium and 10 min in alcohol. Three rectangular acrylic stencils were designed to be 60 mm long x 30 mm wide and 15 mm thick with 5 mm separation perforations. The 15 mm high metal pins are made of a 1.2 mm diameter round stainless steel wire, the perforations are fixed with transparent self-curing acrylic, and the elastomeric chain samples will be pulled.

The tensile strength of a Universal Machine was evaluated, which was previously requested by the Engineering Laboratory. Data collection sheets were used, and the tensile strength of all elastomeric chains immersed in artificial saliva, ammonium, and alcohol at different times was noted: Initial time, 7 days, 14 days, 21 days, and 28 days.

Validation: It does not apply; it does not go through the reliability process since the validation is concrete and objective.

Reliability: It does not apply; it does not go through the reliability process since the validation is concrete and objective.

5. Results

In the present work, the tensile strength in gF of 90 fragments of gray elastomeric chains, a short section of three commercial brands: American Orthodontics (AO), GC Orthodontics (GC) and Rocky Mountain (RMO) immersed in artificial saliva and disinfected with quaternary ammonium (10min) and 70% alcohol (10min) in six-time intervals: initial, 24h, 7 days, 14 days, 21 days and 28 days.

The average values and standard deviations of the tensile strength of the elastomeric chains of the RMO group in the different time intervals are reported, where it is observed that in the RMO – Saliva group in Table 2 at baseline presented the highest value of the mean with a value of 429.50gF ± 3.32 and the lowest value at 28 days with a value of 275.12 ± 20.30; for the RMO - Alcohol group, Table 3 showed the highest value of the mean with 428.79 gF± 5.10 and the lowest value in the 28-day time with a mean value of 260.64 ± 47.27; in the RMO-Ammonium group in Table 4, the highest of the mean was presented at the beginning with a value of 429.40 gF ± 5.10 and the lowest value in the group at 28 days with 266.05 gF ± 38.45.

Table 5 shows that in the GC-Saliva group, the initial time presented the highest value of the mean with a value of 371.69 ± 3.63 and the lowest value at 28 days with a value of 194.05 ± 5.18; for the GC-Alcohol group, Table 6 showed the highest mean value of 375.26 ± 3.11 and the lowest value in the 28-day time with a mean value of 203.74 ± 4.16; in the GC-Ammonium group in Table 7 the highest of the mean was presented at the beginning with a value of 367.41 ± 7.12 and the lowest value in the group at 28 days with 201.80 ± 10.05.

Table 2. Tensile strength of the RMO chain – control group (Saliva)

SALIVA						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	429.50	3.32	434.40	422.16	427.13	431.88
24 hours	400.55	8.01	409.93	381.37	394.81	406.28
7 days	377.60	12.68	392.59	357.92	368.53	386.67
14 days	353.54	11.89	368.12	334.47	345.03	362.04
21 days	315.71	17.22	337.53	286.54	303.39	328.02
28 days	275.12	20.30	299.80	233.52	260.60	289.64

Table 3. RMO chain tensile strength - Alcohol

ALCOHOL						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	428.79	7.74	435.42	409.93	423.25	434.33
24 hours	391.47	4.18	396.67	383.41	388.48	394.46
7 days	343.95	14.82	378.31	322.23	333.35	354.55
14 days	311.93	17.94	334.47	267.17	299.10	324.77
21 days	298.57	22.83	320.19	236.57	282.24	314.90
28 days	260.64	47.27	389.53	218.22	226.82	294.46

Table 4. Tensile strength of RMO chain - Ammonium

Ammonium						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	429.40	5.10	436.44	420.12	425.75	433.05
24 hours	393.51	6.05	401.77	383.41	389.18	397.84
7 days	360.67	9.52	378.31	347.72	354.69	354.69
14 days	342.12	11.16	358.94	328.35	334.13	350.10
21 days	319.37	12.94	341.60	299.80	310.12	328.63
28 days	266.05	38.45	371.18	231.48	238.54	293.55

Table 5. GC chain tensile strength - Saliva

SALIVA						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	371.69	3.63	377.29	366.08	369.09	374.29
24 hours	315.29	4.24	322.23	307.95	312.26	318.33
7 days	277.98	13.61	305.91	264.11	268.24	287.71
14 days	253.81	11.78	275.32	236.57	245.38	262.23
21 days	232.40	7.42	246.77	222.30	227.09	237.70
28 days	194.05	5.18	199.86	186.61	190.35	197.76

Table 6. GC chain tensile strength - Alcohol

ALCOHOL						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	375.26	3.11	380.35	370.16	373.03	377.48
24 hours	321.92	3.26	325.29	317.13	320.18	324.74
7 days	295.82	5.80	304.90	287.56	291.00	300.44
14 days	281.75	24.77	349.76	264.11	264.03	299.47
21 days	235.25	8.56	251.87	220.26	229.13	241.37
28 days	203.74	4.16	209.04	195.79	200.76	206.71

Table 7. GC chain tensile strength - Ammonium

Ammonium						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	367.41	7.12	375.26	353.84	362.32	372.50
24 hours	321.11	4.42	325.29	312.03	317.95	324.27
7 days	286.44	10.02	300.82	265.13	279.27	293.61
14 days	270.64	9.10	285.52	262.07	264.13	277.14
21 days	246.67	10.56	271.24	233.52	239.12	254.22
28 days	201.80	10.05	222.30	186.61	194.61	208.99

Table 8. Tensile strength of AO chain - Saliva

SALIVA						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	439.70	8.01	451.73	428.28	433.97	445.43
24 hours	383.41	11.33	398.71	367.10	375.31	391.52
7 days	334.37	5.59	342.62	324.27	330.37	338.37
14 days	314.07	8.55	329.37	300.82	307.96	320.18
21 days	299.19	11.20	320.19	280.42	291.17	307.20
28 days	243.30	9.99	263.09	230.46	236.15	250.45

Table 9. Tensile strength of AO chain - Alcohol

ALCOHOL						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	441.84	7.29	451.73	428.28	436.63	447.06
24 hours	405.34	4.31	410.95	396.67	402.26	408.42
7 days	335.49	11.64	351.80	318.15	327.16	343.81
14 days	316.62	7.87	332.43	303.88	310.99	322.25
21 days	296.33	11.12	318.15	285.52	288.38	304.29
28 days	244.12	7.59	251.87	233.52	238.69	249.55

Table 10. Tensile strength of AO chain - Ammonium

Ammonium						
	Mean	**SD**	**Max**	**Min**	**[95% conf. Interval]**	
Beginning	445.29	8.09	457.85	434.40	440.21	450.37
24 hours	398.00	5.61	408.91	391.57	393.98	402.01
7 days	360.98	5.93	368.12	347.72	356.74	365.22
14 days	339.57	7.26	355.88	333.45	334.38	344.76
21 days	297.66	5.19	306.93	290.62	293.95	301.37
28 days	261.05	7.45	273.28	245.75	255.72	266.38

Table 11. Evaluation of the alteration of the tensile strength of RMO brand elastomeric chain disinfected with ammonium at six different times: initial, 1 day, 7 days, 14 days, 21 days and 28 days

RMO							
	Saliva		Alcohol		Ammonium		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**P**
Beginning	429.50	3.32	428.79	7.74	429.40	5.10	0.78
24 hours	400.55	8.01	391.47	4.18	393.51	6.05	0.01*
7 days	377.60	12.68	343.95	14.82	360.67	9.52	0.00*
14 days	353.54	11.89	311.93	17.94	342.12	11.16	0.00**
21 days	315.71	17.22	298.57	22.83	319.37	12.94	0.03**
28 days	275.12	20.30	260.64	47.27	266.05	38.45	0.04**
P	0.00**		0.00**		0.00**		
Anova test*. Kruskal Wallis test. (p<0.05)**							

Table 12. Evaluation of the alteration of the tensile strength of GC brand elastomeric chain disinfected with ammonium at six different times: initial, 1 day, 7 days, 14 days, 21 days and 28 days

GC							
	Saliva		Alcohol		Ammonium		
	Mean	SD	Mean	SD	Mean	SD	P
Beginning	371.69	3.63	375.26	3.11	367.41	7.12	0.01**
24 hours	315.29	4.24	321.92	3.26	321.11	4.42	0.00*
7 days	277.98	13.61	295.82	5.80	286.44	10.02	0.00*
14 days	253.81	11.78	281.75	24.77	270.64	9.10	0.00**
21 days	232.40	7.42	235.25	8.56	246.67	10.56	0.00**
28 days	194.05	5.18	203.74	4.16	201.80	10.05	0.01**
P	0.00**		0.00**		0.00**		
Anova test*. Kruskal Wallis test. (p<0.05)**							

Table 13. Evaluation of the alteration of the tensile strength of AO brand elastomeric chain disinfected with ammonium at six different times: initial, 1 day, 7 days, 14 days, 21 days and 28 days

AO							
	Saliva		Alcohol		Ammonium		
	Mean	SD	Mean	SD	Mean	SD	P
Beginning	439.70	8.01	441.84	7.29	445.29	8.09	0.29
24 hours	383.41	11.33	405.34	4.31	398.00	5.61	0.00**
7 days	334.37	5.59	335.49	11.64	360.98	5.93	0.00**
14 days	314.07	8.55	316.62	7.87	339.57	7.26	0.00**
21 days	299.19	11.20	296.33	11.12	297.66	5.19	0.80
28 days	243.30	9.99	244.12	7.59	261.05	7.45	0.00**
P	0.00**		0.00**		0.00**		
Anova test*. Kruskal Wallis test. (p<0.05)**							

In Table 8 it is observed that in the AO – Saliva group, the initial time presented the highest value of the mean with a value of 439.70 ± 8.01 and the lowest value at 28 days with a value of 243.30 ± 9.99; for the AO – Alcohol group in Table 9 in the initial time the highest value of the mean was observed with 441.84 ± 7.29 and the lowest value in the time of 28 days with a mean value of 244.12 ± 7.59; in the AO – Ammonium group in Table 10, the highest of the mean was presented at the beginning with a value of 445.29 ± 8.09 and the lowest value in the group at 28 days with 261.05 ± 7.45.

Tables 11 and 12 show the results of the ANOVA test. This statistical analysis showed statistically significant variations ($p<0.05$) when comparing the average tensile strength values of the elastomeric chains of the RMO and GC group immersed in saliva, alcohol and ammonium at 24 hours and 7 days. In addition to Kruskall Wallis' analysis for two factors, he found that the variables time and disinfectants ($p = 0.00$) show an effect on the alteration of the tensile strength of the GC, RMO and AO brand elastomeric chains in Tables 11, Table 12 and Table 13.

At 24 hours of the experiment, an average decrease in tensile strength was found in the control group of 15.2%, 6.7% and 12.8% and at 28 days, a greater decrease of 47.8%, 35.9% and 44.7% for the GC, RMO and AO groups respectively. When disinfecting the elastomeric chains with 70% alcohol, the average decrease in tensile strength at 24 hours was 14.2% GC, 8.7% RMO, 8.3% AO and at 28 days 45.7% GC, 39.2% RMO and 44.7% AO; when disinfecting with quaternary ammonium, traction decreased by 12.6% GC, 8.4% RMO and 10.6% AO and at 28 days by 45.1% GC, 38% RMO and 41.4% AO. RMO elastomeric chains presented the highest initial traction in gf compared to AO and GC chains, the latter having the lowest initial traction evaluated. This pattern was reproduced in all six time periods throughout the study in both the control group and the Quaternary Alcohol and Ammonium groups.

In the Tables 11, 12, and 13, statistically significant differences were observed in terms of disinfectants between the times 1 day, 7 days, 14 days, 21 days and 28 days. Likewise, according to each disinfectant, statistically significant differences were found in the alteration over time.

Likewise, according to each disinfectant, statistically significant differences were found in the alteration over time. For the evaluation of the alteration of the tensile strength of GC, RMO and AO elastomeric chains immersed in artificial saliva at six different times: initial, 1 day, 7 days, 14 days, 21 days and 28 days, it was used in Kruskall Wallis analysis for two factors, where it was found that the variables time with a value of $p = 0.00$ and disinfectants with a value of $p = 0.00$ show an effect on the alteration of the tensile strength of elastomeric chains.

6. Discussion

It is important to evaluate the behavior of the elastomeric chains since they can be altered by various environmental factors such as saliva, diet, brushing, mouthwashes and disinfection, causing rapid degradation of the traction force, which can compromise the result of the treatment [9, 11, 13, 14, 18, 43]. Due to the COVID-19 pandemic, disinfection measures were increased to reduce the high rate of infections.

In addition, in our clinical practice, the high turnover of patients and the continuous handling of materials that are not individualized, such as elastomeric chains, have delayed the use of different disinfectants between patients [1, 3, 6]. In our work, we evaluated the effects of disinfection with quaternary ammonium and 70% alcohol on the tensile strength of elastomeric chains in six time intervals: initial, 1 day, 7 days, 14 days, 21 days and 28 days.

Many researches have shown that 70% alcohol is widely used by professionals due to the ease of use and low cost [18] and quaternary ammonium that became better known during the COVID-19 pandemic, both intermediate-level disinfectants recommended by the CDC. In Mattos' investigation [18], disinfection of elastomeric chains with quaternary ammonium and 70% alcohol decreased tensile strength in the first 24 hours and at 28 days, similar to the control group (artificial saliva) that did not have any disinfection. These results parallel evaluations by Ebrahiminik et al. that the AO brand elastomeric chains immersed in saliva also decreased in tensile strength.

However, Mattos' assessment [18] showed no statistically significant difference. Halimi mentions in his study that the Strength of chains submerged in artificial saliva decreases from 56% to 91% after four weeks[24]. We found a decrease of almost 50% at 28 days of the study. Aphiwantanuk investigated the effect of 70% alcohol for 1 min, chlorhexidine for 10 min, and quaternary ammonium as aluminium for 10 min on elastomeric chains of the AO(American Orthodontics) OC (Ormco) and OS (Sino Ortho) and concluded that it does not produce significant differences in the initial tensile strength. Phiton et al. also studied the effects of 70% alcohol on the mechanical properties of elastomeric chains. They found no reduction in initial retraction, like our study with the AO and RMO brands.

However, at 24 hours, 7 days, 14, 21 and 28 days, our study found that there is a statistically significant difference in the elastomeric chains disinfected with 70% alcohol. These results were possibly evidenced because the chains were submerged in artificial saliva at 37 C for the entire time of the study to simulate the oral environment similar to human temperature [9, 13, 14, 18, 27].

On the other hand, Osorio's study evaluated the disinfection of the elastomeric chains with 70% alcohol, 2% glutaraldehyde and enzymatic detergent for 30 min, concluding that 70% alcohol did significantly affect the tensile force of the chains since polymers are sensitive to the effects of free radicals such as ozone and oxygen producing a decrease in the traction and flexibility of the chains[11].

This was an in vitro study due to the ease of standardizing the environment, since humid environments promote greater degradation of elastomeric chains, however, there may be some differences with in vivo studies, producing a greater decrease in strength. The disinfectants used in this study caused a statistically significant reduction in the tensile strength of the elastomeric chains compared to the control group that was not exposed to any disinfectant. Quaternary ammonium was the disinfectant that caused the least alteration of the tensile force compared to 70% alcohol.

The highest percentage decrease in tractive force was at 28 days, almost 50% in all groups studied. All three chain brands used in this study had a reduction in tensile strength that was statistically significant over all six-time intervals. With the RMO brand having the least alteration, followed by AO and finally GC with the greatest alteration, it could be because the internal composition of the chains is determined by the quality of the raw material used by each company[18], especially because of the glass transition temperature, having a higher temperature the polymer is stiffer. It has a higher tensile strength[11]. Also, they have had no quality control many times [18]. Biosafety in orthodontics must be made known among professionals, and each patient must be treated as infected since many infections present do not give signs or symptoms [1, 2].

7. Conclusion

To avoid cross-contamination and COVID-19 between patients, it is necessary to disinfect the elastomeric chains prior to use in the mouth. A statistically significant difference was found in the decrease in tensile strength in elastomer chains disinfected with 70% alcohol and quaternary ammonium as in the control group (artificial saliva).

Different groups were analyzed, and each showed a progressive decrease in traction at the six time intervals. GC elastomeric chains showed the highest tensile force degradation in the six time intervals. RMO elastomeric chains performed best at all time intervals. This finding could justify using quaternary ammonium in orthodontic procedures as it does not alter the tensile strength as much as alcohol. It is recommended that more studies be done with other brands of chains and disinfectants.

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