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Original Article

The Effect of Sodium Lauryl Sulfate on Orthodontic Elastic Latex's & Non-Latex's Tensile Strength

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Abstract

Background : Orthodontic elastic is one of the tools used in orthodontic treatment. Based on the type of material, orthodontic elastics are divided into latex & non-latex. Clinically, orthodontic elastic has decreased tensile strength which can be influenced by various factors including salivary pH and the use of toothpaste. The content of SLS in toothpaste can increase the pH of saliva, causing a decrease in tensile strength. This study aims to analyze the effect of Sodium Lauryl Sulfate on the elastic tensile strength of latex and non-latex orthodontics.

Methods : This is an experimental laboratory research with post-test only control group design. The research samples consisted of 15 samples of orthodontics elastics latex and 15 samples of orthodontics elastics non-latex of AO brand with diameter ¼ inches. The samples were divided into 3 groups with latex and non-latex variations in each group, the samples was soaked for 24 hours. Tensile strength was measured using Imada Motorized Tensile Test MV 110. The statistic used one way Anova test.

Results : One way Anova test showed that there was no significant difference between the control group, detergent toothpaste group and non-detergent toothpaste group with $p = 0.757$ ($p > 0.05$) for latex and $p = 0.382$ ($p > 0.05$) for non-latex.

Conclusion : Detergent and non-detergent toothpaste did not affect the tensile strength of orthodontic elastic latex and non-latex.

Keywords : Tensile strength, sodium lauryl sulfate, orthodontic elastic

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INTRODUCTION

According to the World Health Organization (WHO), malocclusion is an anomaly or abnormality that causes complaints, damage, or occlusion dysfunction.[1] The prevalence of malocclusion in Indonesia reached 80% and placed third in oral health problems, following caries and periodontal disease.[2,3] This high prevalence of malocclusion leads to a high demand for orthodontics treatment, especially in adolescents.[4] Orthodontics treatment can be carried out using fixed and removable appliances. One of the main components of fixed orthodontic appliances is orthodontic elastic.[5]

Orthodontic elastics are used to aid in closing interproximal space and provide intermaxillary fixation in bone fracture cases or orthodontic treatment.[6] Its advantages include relatively cheap price, high flexibility, and the ability to return to its original dimension after a significant stretching.[6]

Orthodontic elastic needs to maintain its tensile strength to provide an ideal result. Clinically, orthodontic elastic shows a decrease in tensile strength.[7] This decrease can be affected by the type of material, saliva, potential of Hydrogen (pH), changes in temperature, enzyme, microbes, duration of stretching, food and drink consumption, and the use of oral hygiene products.[7–9]

The most commonly used oral hygiene product is toothpaste. Commercial toothpaste comprises various brands and compositions.[10] The ingredients contained in toothpaste can alter the pH of saliva. Aside from toothpaste, salivary pH can also be affected by diet, stimulation of salivary secretions, salivary flow rate, microorganisms, and buffer capacity.[11,12] Increased salivary pH due to the use of toothpaste is caused by the ingredients contained in toothpaste, including Sodium Lauryl Sulfate (SLS).[13]

SLS is one of the detergents used as an active ingredient in toothpaste, which functions to help release food debris and plaque adhering to the tooth surface. SLS can only be found in toothpaste with detergent.[14] According to Yustika, toothpaste containing SLS can significantly increase salivary pH compared to non-SLS toothpaste.[15]

Choice of toothpaste needs to be considered, due to different oral hygiene needs between individuals, especially in orthodontics appliance users. Orthodontic appliance users need to consider the ingredients contained in toothpaste to minimize the side effects of the interaction between fixed orthodontics appliances and toothpaste ingredients. Many studies related to the effect of toothpaste ingredients such as fluoride and colostrum on orthodontic appliances have been conducted. However, none of the studies directly evaluate the effect of sodium lauryl sulfate on the tensile strength of latex and non-latex orthodontic elastics. This is important to help orthodontic appliance users choose the appropriate toothpaste to minimize frequent replacement of orthodontic elastics.

METHODS

This study uses a laboratory experiment with a post-test-only control group design. It was conducted in the Biochemical Laboratory of the Faculty of Medicine and the Mechanical Engineering Laboratory of Diponegoro University between June and July 2022. The study received ethical clearance from the Health Research Ethical Committee of the Faculty of Medicine of Diponegoro University No. 70/EC/H/FK-UNDIP/VII/2022. The samples were latex and non-latex orthodontic elastics chosen through simple random sampling. They were divided into three treatment groups with a variation of latex and non-latex elastics in each group. The group contained 15 latex and 15 non-latex ¼ inch medium force orthodontic elastics from American Orthodontics with 4.5 oz power. Samples were to be stretched in an acrylic board by a distance of 19.05 mm and immersed for 24 hours at 37°C.

Sample Preparation

The samples were 15 latex and 15 non-latex ¼ inch medium force orthodontics elastics from American Orthodontics with 4.5 oz power. The samples were to be stretched on an acrylic board made by adjusting the stretching distance of the elastics three times its diameter, which was 19.05 mm. The acrylic boards were labeled according to the three treatment groups, the control group, the detergent toothpaste group, and the non-detergent toothpaste group.

Sample Immersion

There were three different immersion solutions : 1) Control group : Artificial saliva; 2) Detergent toothpaste treatment group : Artificial saliva + detergent toothpaste (Pepsodent®); 3) Non-detergent toothpaste treatment group : Artificial saliva + non-detergent toothpaste (Enzim®).

One-point-five grams of detergent and non-detergent toothpaste were prepared and diluted into 25 ml of artificial saliva with a pH of 6.7 in a prepared beaker glass. The solutions in each treatment group were checked for pH with a pH meter (Hanna®) and incubated at 37°C for 24 hours using the Memmert IN55 incubator. The artificial saliva used in this study was formulated according to the Fusayama-Meyer method by mixing KCl (400 mg/L), NaCl (400 mg/L), $CaCl_2.2H_2O$ (906 mg/L), $NaH_2PO_4.2H_2O$ (690 mg/L), $Na_2S.9H_2O$ (5 mg/L), and Urea (1000 mg/L).

Measurement of Tensile Strength

Tensile strength measurement requires a puller hook to pull orthodontic elastics. The hook was made using

U-shaped 0.8 mm stainless steel clasps, which were placed into the Imada Motorized Tensile Test MV 110. Tensile strength was measured by placing the samples on the puller hook. The initial strength of latex and non-latex orthodontic elastics was measured in advance before tensile strength measurements in treatment groups. After the samples were placed in the puller hook, the Imada Motorized Tensile Test MV 110 would pull the samples until they broke and the tensile strength was recorded in the device's monitor.

Statistical Analysis

The obtained data were analyzed using the IBM SPSS Statistics version 26. Statistical analyses include the Shapiro-Wilk normality test, Levenne's homogeneity test, and the One-Way ANOVA parametric test.

RESULTS

The initial tensile strength from latex and non-latex orthodontic elastics is presented in Table 1. Table 1 and Table 2 showed that the tensile strength of latex and non-latex elastics experienced a decrease after 24-hour immersion at 37°C. The largest decrease in tensile strength was 24.21%, which was found in the latex elastics immersed in artificial saliva mixed with detergent toothpaste. The mean and standard deviation chart of the tensile strength of orthodontic elastics can be seen in Figure 1.

The analysis shown in Table 3 using the Shapiro-Wilk normality test and Levenne's homogeneity test showed a significance value of $p > 0.05$. This concluded that the data were normally distributed and

TABLE 1
The initial strength of orthodontic elastics

Group	Tensile Strength (MPa)
Latex Orthodontic Elastics	15.95
Non-Latex Orthodontic Elastics	9.13

TABLE 2
Mean and standard deviation (SD) of tensile strength

Group		Sample Size	Mean ± SD (MPa)
Latex	Control	5	12.82 ± 1.44
	Detergent Toothpaste	5	12.09 ± 1.74
	Non-detergent Toothpaste	5	12.71 ± 1.75
Non-Latex	Control	5	8.17 ± 0.35
	Detergent Toothpaste	5	7.93 ± 0.12
	Non-detergent Toothpaste	5	8.09 ± 0.29

TABLE 3
The percentage of orthodontic elastics' tensile strength decreases

Group		Tensile Strength Decrease %
Latex	Control	19.62%
	Detergent Toothpaste	24.20%
	Non-detergent Toothpaste	20.31%
Non-Latex	Control	10.50%
	Detergent Toothpaste	13.14%
	Non-detergent Toothpaste	11.39%

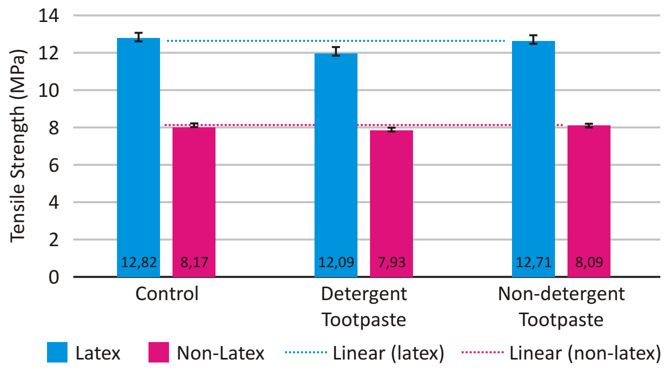

Figure 1. Mean and standard deviation chart of tensile strength.

TABLE 4
Shapiro-Wilk and Levenne's tests

Group		p^a	p^b
Latex	Control	0.449*	0.703*
	Detergent Toothpaste	0.815*	
	Non-detergent Toothpaste	0.061*	
Non-Latex	Control	0.167*	0.307*
	Detergent Toothpaste	0.196*	
	Non-detergent Toothpaste	0.994*	

*Normal/homogenous ($p > 0.05$), [a]Shapiro-Wilk, [b]Levenne's test

TABLE 5
One-Way ANOVA

Group		p
Latex	Control	0.757*
	Detergent Toothpaste	
	Non-detergent Toothpaste	
Non-Latex	Control	0.382*
	Detergent Toothpaste	
	Non-detergent Toothpaste	

*Normal/homogenous ($p > 0.05$), [a]Shapiro-Wilk, [b]Levenne's test

TABLE 6
The results of the pH test

Group	Tensile Strength (MPa)
Artificial Saliva	6.7
Artificial Saliva + Detergent Toothpaste	7.9
Artificial Saliva + Non-detergent Toothpaste	7.6

homogenous. Data were further analyzed with One-Way ANOVA, which was shown in Table 4 with a significance value of p >0.05. This concluded that there were no significant differences in the tensile strength of orthodontic elastics between different treatment groups. The pH results in Table 5 indicated a pH of 6.7 for artificial saliva, 7.9 for artificial saliva + detergent toothpaste, and 7.6 for artificial saliva + non-detergent toothpaste.

DISCUSSION

In its application, orthodontic elastic underwent a decrease in tensile strength.[7] This decrease can be affected by several factors, including solution pH, enzyme, duration of stretching, the use of oral hygiene products, to composition and brand from orthodontic elastics.[7–9,16] Toothpaste is a common oral hygiene product. It is used to clean and control plaque in the oral cavity.[17,18] In general, toothpaste comprises several ingredients, such as abrasive, humectant, bonding agent, water, flavorings and sweeteners, coloring, active ingredients, gel, and surfactant or detergent.[14] These ingredients can affect salivary pH.[15] The measurement in artificial saliva mixed with detergent toothpaste showed an increase in pH to 7.9 and an increase to 7.6 for artificial saliva mixed with non-detergent toothpaste.

The results of One-Way ANOVA revealed a p-value of >0.05, which indicated no significant differences between treatment groups. Sumekar and Suparwitri stated that pH only affects the tensile strength of latex orthodontic elastics after 24 hours of immersion.[7] This was in line with Yuwana, *et al*. who found a significant difference between treatment groups after 48 hours of immersion.[19] The pH obtained between detergent and non-detergent toothpaste solution did not differ much and thus did not cause a significant difference in tensile strength. This result can also be explained by the micelle concentration of SLS which was only 7 mM/L. This concentration is not enough to denature or change the structure of the polypeptide chain in the proteins in latex and non-latex orthodontic elastics.[20]

Detergents with micelle concentration under the critical level could not denature proteins. This is because micelle acts as a denaturant.[20] The ability to denature proteins derived from the amphiphilic nature of detergent. SLS will bind proteins through the interaction between sulfate groups and the positively-charged amino acid side chains, and between alkyl chain and hydrophobic side chains.[20] the micelle concentration in the SLS contained in toothpaste in this study could not be exactly known. This insignificant result could also be caused by thickness differences within the same brand of orthodontic elastics. Thickness differences can cause a difference in the cross-sectional area of orthodontic elastics. This can affect the forces produced by the elastics, thus causing insignificant changes in the tensile strength of orthodontic elastics.[21]

A tensile strength decrease was also found in the control group. This may be due to the effect of stretching and immersion duration. Orthodontic elastics showed a 10–40% decrease in tensile strength from the initial strength after immersion in saliva for 30 minutes to the first 24 hours.[22,23] In non-latex orthodontic elastics, the reduction of tensile strength occurred because the chemical structure of non-latex orthodontic elastics comprised of hydrogen and Van der Waals bond, which is relatively weak in maintaining strength and elasticity from polymers.[7]

CONCLUSION

This article concludes that sodium lauryl sulfate does not affect the tensile strength of latex and non-latex orthodontic elastics. The insignificant difference can be caused by the use of commercially available toothpaste, which leads to uncontrolled and unknown SLS concentrations. This study could not be generalized using other brands of orthodontic elastics due to the different formulas and manufacturing processes of elastics from each brand. This study suggests a further study using measured SLS concentration and variations in orthodontic elastic brands.

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