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# In vitro comparison of the tensile strength of elastomeric ligatures exposed to Povidone Iodine 1%, Chlorhexidine 0.02%, and hydrogen peroxide 5%

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## Summary

**Objective** > In orthodontic patients using any chemical substances in oral environment could change the elastomeric properties of their appliances. Since the beginning of the SARS-CoV-2 pandemic, efforts have been devoted to explore methods of prevention including the use of antiviral mouthwashes. This study aimed to investigate the effects of Povidone Iodine (PVP-I) and two other disinfecting solutions on the mechanical properties of orthodontic elastomeric ligatures.

**Materials and methods** > In this study, 130 elastomeric ligatures in five groups (three test groups and two control groups) were examined in laboratory conditions for a period of 28 days. In the control group, specimens were kept dry in a dark environment while all other ligatures were stored in artificial saliva. Elastomeric ligatures were immersed into PVP-I solution (1%) Chlorhexidine (0.02%), and hydrogen peroxide (5%) for one minute each day in three time intervals of one day, 7 days and 28 days. Next, the maximum tensile strength of elastomeric ligatures was tested by a universal testing machine (CN 1174, Germany).

**Results** > The results showed that the tensile strength of elastomeric ligatures was significantly decreased in all three test groups after 28 days (p-value < 0.05). However, the difference between groups was not statistically significant. Between-subject ANOVA test showed that there were significant correlations between the time of exposure and type of disinfecting solutions.

**Conclusions** > PVP-I has comparable effects on elastomeric ligatures as artificial saliva, chlorhexidine, and hydrogen peroxide.

## Introduction

In fixed orthodontic treatment, elastomeric ligatures are commonly used to tie the archwire to the brackets [1]. The force exerted by these elastomeric materials is clinically determinant of tooth movement and could be changed by different environmental factors. Exposure of these elastomeric ligatures to the chemical solutions could adversely affect the quality of the orthodontic treatment. However, due to some circumstances, different kinds of mouthwashes might be prescribed during orthodontic treatment. As an instance, Chlorhexidine (CHX) is commonly prescribed for patients with poor oral hygiene and gingivitis. Since the beginning of the SARS-CoV-2 pandemic in late 2019, several studies showed that the oral cavity could act as a reservoir for the virus with a number of studies reporting elevated salivary viral titres among COVID-19 positive patients [2,3]. Anderson et al. reported that viral loads at the oropharynx and nasopharynx are high with the result that saliva contains up to  $1.2 \times 10^8$  infective copies/per ml [4]. The virus is highly transmissible before, during, and after the acute clinical phase of the disease [5]. Thus, it is imperative to establish measures to reduce the oral cavity viral load to first, decrease the pathogenicity and severity of the disease and second, to reduce the transmission of the virus and appropriate mitigation of further virus spread. Different mouthwashes have been suggested to have antiviral activities. Mateos-Morenos et al. reported that the three most recommended oral antiseptics in the scientific works against SARS-CoV-2 have been PVP-I, HP, and CPC [6]. Kumar et al. reported that Shelanski was the first in 1950 to introduce PVP-I to the pharmaceutical market as an antiseptic agent with a variety of applications in medicine and dentistry [7]. PVP-I is a water-soluble complex with powerful antibacterial and antiviral activities [8–10]. Davies et al. demonstrated effective inactivation of SARS-CoV-2 mouthwashes containing 0.01–0.02% hypochlorous acid or 0.58% PVP-I [11]. Also, nasal and oral decontamination with PVP-I as part of a preventive plan to reduce the likelihood of virus transmission has been suggested to the frontline providers [9,10,12]. Furthermore, ADA guidelines for minimizing the risk of COVID-19 transmission recommended the use of PVP-I mouthwash prior to all dental procedures [13–15]. The aim of this study was to evaluate the effects of PVP-I on the maximum tensile force of elastomeric ligatures comparing with conventional mouth rinses including chlorhexidine (CHX) and hydrogen peroxide (HP).

## Materials and methods

In this lab trial study, 130 injection-molded grey elastomeric ligatures (American Orthodontics, Sheboygan, USA) were used (sample size was calculated based on a similar study [16] assuming  $\alpha=0.05$ , and study power of 85%).

To simulate the clinical application and stretching of ligatures, samples were engaged on the first maxillary premolar brackets (0.022-inch slot; Dentaaurum, Ispringen, Germany) and divided into 4 groups of 30. Also, a subgroup of 10 ligatures stored dry in a dark room ( $22 \pm 2$  °C temperature, 30% humidity) representing the tensile force of as-received from the manufacturer which normally is in the range of 22–25 N [16]. The control group was a number of 30 ligatures incubating in artificial saliva and unexposed to any disinfectants.

In test groups, all 120 elastomeric ligatures were immersed in artificial saliva bottles; each bottle contained 10 elastomeric ligatures. The bottles were then stored at 37 degree C for 28 days with intermittent interventions. The artificial saliva used in the present study consisted of 1 g sodium carboxymethylcellulose, 0.1 g potassium chloride, 4.3 g xylitol, 5 mg calcium chloride, 1 mg potassium thiocyanate, 40 mg potassium phosphate, and 100 g distilled deionized water which was synthesized in the biology laboratory at Aja university of medical sciences. The artificial saliva was changed daily during the period of the experiment. Intervention in study groups was to expose the ligatures to one of the following disinfecting solutions:

- G1: PVP-I 1% (Kimia Darou Sepehr, Iran);
- G2: CHX 0.02% (Irsha, Tehran, Iran);
- G3: HP 0/5% (Sepidaj pharmaceutical company, Iran).

At the beginning of the study, 10 elastomeric ligatures of each study group were immersed in the relevant disinfecting material for one minute, washed out and replaced backed to the artificial saliva. That was repeated for 7 days in the second subgroups ( $n = 10$ ) and 28 days for the third subgroups ( $n = 10$ ) of each study group.

On the day 28, all the ligatures were removed from the brackets with the help of a probe by the same operator and transferred to the Instron universal testing machine (CN 1174, Germany) to evaluate the maximum tensile force at failure in Newton (N). Collected data were entered to a computer using SPSS version 18 software and analysed by within-subject and between-subject ANOVA tests considering a significant level of 0.05.

## Results

The results for the maximum tensile load at failure testing are shown in table 1. The mean tensile load at failure of ligatures kept dry was  $21.21 \pm 1.45$  N representing tensile strength of as-received ligatures. Within-subject ANOVA test showed significant differences in tensile strength of ligatures with different exposure times. In each study group tensile load became significantly less as the time of exposure increased (P-value; G1: 0.005, G2: 0.008 and G3: 0.001). However, there were no significant differences between the type of disinfectants in each time point (P-value; Day1: 0.810, Day 7: 0.610, Day 28: 0.250). A between-subjects ANOVA test showed significant interactions (P-value: 0.0001) between disinfectant and time. Ligatures

TABLE I  
Descriptive statistics of study samples.

Study groups	Mean Tensile force (N <sup>a</sup> ) at failure $\pm$ SD					P-value <sup>b</sup>	P-value <sup>c</sup>
	As-received ( <i>n</i> = 10)	Day 1	Day 7	Day 28			
G1 (PI) ( <i>n</i> = 30)	21/21 $\pm$ 1./45	90/0 $\pm$ 58/19	92/0 $\pm$ 04/17	18/67 $\pm$ 1/03	0/005		0/001
G2 (CHX) ( <i>n</i> = 30)	21/21 $\pm$ 1./45	92/0 $\pm$ 63/19	94/0 $\pm$ 08/17	23/1 $\pm$ 41/18	0/008		
G3 (HP) ( <i>n</i> = 30)	21/21 $\pm$ 1./45	08/1 $\pm$ 50/19	59/0 $\pm$ 50/16	31/1 $\pm$ 25/18	0/001		
Control ( <i>n</i> = 30)	21/21 $\pm$ 1./45	21/02 $\pm$ 1/30	19/52 $\pm$ 0/52	20/06 $\pm$ 0/70	0/006		
P-value <sup>b</sup>	–	810/0	0/250	610/0	–		

<sup>a</sup>Newton.

<sup>b</sup>Within-subject ANOVA.

<sup>c</sup>Between-subject ANOVA.

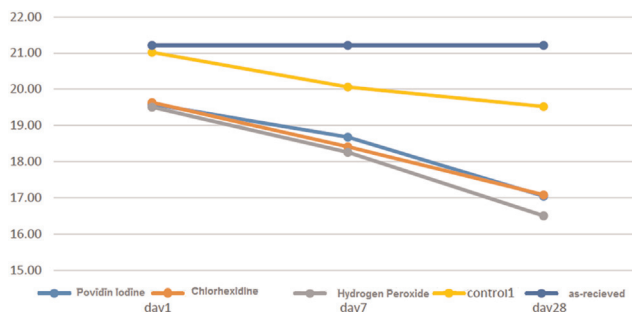


FIGURE 1  
The maximum tensile force at failure (N) of elastomeric ligatures

stored in a dark dry condition exhibited the greatest tensile load at failure ( $21.21 \pm 1.45$  N) and those exposed to HP for 28 days showed the least ( $16.50 \pm 0.59$  N).

ANOVA test indicated that ligatures exposed to any disinfection solutions of this study exhibited significantly lower failure loads compared to as received-ligatures ( $P < 0.05$ ). This difference was revealed to be more significant as the time of exposure increased (figure 1).

## Discussion

To tie the archwire to the brackets, elastomeric ligatures are commonly used by orthodontists due to their several advantages including easy application, low cost, patient comfort, and satisfaction [1]. The only drawback of these elastomeric ligatures is the force degradation and colour changes over the time. The reason is the polyurethane which could be decomposed under different environmental conditions such as temperature changes, pH variations, tooth movement, oral rinses, salivary enzymes, and masticatory forces [1,16,17]. In this study, immersion of elastomeric ligatures into CHX 0.2%, PVP-I 1%, and HP

0.5% decreased the maximum tensile force at failure of the elastomeric ligatures after 28 days similar to the control group that was not exposed to any disinfectants. These findings parallel some of the results from Ahrari et al. which showed that immersion of three different brands of ligatures (American Orthodontics, Ortho Technology, GAC) in artificial saliva significantly decreased the tensile strength [16]. Also, Shilo et al. reported that immersion of American Orthodontics and Sirona Dentsply ligatures in artificial saliva caused significant loss of tensile strength without significant difference between the two brands [17]. Furthermore, Evangelista et al. investigated the effects of two different disinfectant solutions (Vital Defense<sup>TM</sup> and Cidexplus<sup>TM</sup>) on the tensile load at failure of the ligatures for up to 28 days. They reported that the tensile load at failure of ligatures was significantly decreased with time, however there was no significant difference between two types of disinfectant solutions [18]. Similarly, the results of the present study showed that there were no statistically significant differences between the three disinfecting solutions. This is suggestive that the aqueous component or the chemical substances in the different disinfectant solutions may plasticize or cause degradation of the elastomers. Guimaraes et al. explained that penetration of the liquid among the macromolecules of the elastomeric ligatures, produce an internal force that separates chains and expands the polymer by breaking the secondary links resulting in relaxation [19]. It is important to mention that the results of this study must be cautiously interpreted as the investigation has been performed in-vitro and stimulations of some intraoral factors such as a wide range of temperature changes, microorganisms, salivary enzymes, different stretch patterns, etc. was not possible. Although all three materials used in this study caused a reduction in the tensile strength of ligatures, this reduction was similar to the control group which was not exposed to any disinfectants. Thus, it could be concluded that the reduction of tensile strength has been in the accepted clinical range during

the four weeks and consequently must be replaced by new ligatures at each orthodontic visit [20].

Finally, as promising effects of PVP-I against SARS-CoV-2 have been reported by several in vitro and in vivo studies [6,21,22], its routine use during the pandemic in patients with orthodontic appliances could be beneficial without concerns of side effects on the elastomeric properties of the ligatures. However, more studies with larger sample sizes and in clinical trial designs are required to fully understand the effects of the PVP-I and other disinfectants on the elastomeric properties of the ligatures and also their colour changes.

## Conclusions

PVP-I could be safely used in the covid-19 era regarding its effects on maximum tensile strength of elastomeric ligatures as it showed comparable effects as artificial saliva, chlorhexidine, and hydrogen peroxide.

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