Original Article

The effect of pH levels on nonlatex vs latex interarch elastics

Paul S. Sauget[a]; Kelton T. Stewart[b]; Thomas R. Katona[c]

ABSTRACT

Objective: To evaluate the force decay characteristics of nonlatex vs latex interarch elastics within the normal range of salivary pH levels.

Materials and Methods: Two nonlatex groups and one latex quasi-control group were tested. Elastics were stretched to 15 mm and were held for 10 seconds (baseline), 4 hours, 8 hours, and 12 hours in artificial saliva solutions with pH levels of 5.0, 6.0, and 7.5. Force magnitudes were measured at 25 mm of activation. Each specimen was used once. Measurements were assessed using three-way analysis of variance (ANOVA).

Results: The three-way interaction between group, pH, and time was not significant ($P = .13$); the group-by-pH interaction also was not significant ($P = .70$). However, pH-by-time ($P = .0179$) and group-by-time ($P = .0001$) interactions were significant. American Orthodontics nonlatex generated significantly higher loads than Auradonics nonlatex. American Orthodontics nonlatex produced significantly higher forces than American Orthodontics latex at 4, 8, and 12 hours, but not at 10 seconds. American Orthodontics latex was significantly stronger than Auradonics nonlatex at 10 seconds, but not at 4, 8, and 12 hours.

Conclusions: No clinically significant correlation between pH and force decay was observed. (*Angle Orthod.* 2011;81:1070–1074.)

KEY WORDS: Latex; Nonlatex; pH; Force decay

INTRODUCTION

As the result of latex allergies, nonlatex orthodontic interarch elastics are becoming increasingly popular.[1] Several properties of latex and nonlatex elastics have been evaluated,[2–12] some involving saliva or simulated saliva solutions.[2,6–8,13–17] Few studies have investigated the effects of salivary pH levels on viscoelastic force relaxation of nonlatex interarch elastics.[18] Great individual pH variability is noted within the oral cavity, and this can fluctuate with diet. Those who examined the force decay of polyurethane intra-arch chain elastics have concluded that study of the effects of pH at several levels would be the next logical step. Also, comparison of interarch nonlatex elastics vs a latex elastic control at various pH levels has yet to be done. As newer formulations of nonlatex elastics such as polyurethane become more resistant to degradation, they also may become more resistant to force decay.

One study assessed the mechanical properties of latex and nonlatex orthodontic elastics.[6] Although that study compared only one brand of elastics, the authors reported that the former had greater breaking strength than the latter. A study in 2006 stated that nonlatex elastics become more "deformed" with use than latex ones.[13] However, both show loss of force along with an increase in treatment time, and no significant differences were noted between the two within 24 hours. Another study by members of the same group[19] concluded that there are significant differences between latex and latex-free elastics, but latex-free elastics can replace latex products if they are changed more frequently. Kersey et al.[14] compared four brands of nonlatex orthodontic elastics. They measured force decay over a 24-hour period while cyclically stretching the elastics to simulate interarch usage with chewing. The purpose of the present study is to test similar interarch elastics in a static environment to isolate the influence of pH on force decay.

[a] Private practice, Tamuning, Guam.

[b] Assistant Professor, Department of Orthodontics and Oral Facial Genetics, Indiana University School of Dentistry, IUPUI, Indianapolis, Ind.

[c] Associate Professor, Department of Orthodontics and Oral Facial Genetics, Indiana University School of Dentistry; Department of Mechanical Engineering, Purdue University School of Engineering and Technology, IUPUI, Indianapolis, Ind.

Corresponding author: Dr Thomas R. Katona, Indiana University School of Dentistry, IUPUI, 1121 W Michigan St, Indianapolis, IN 46202

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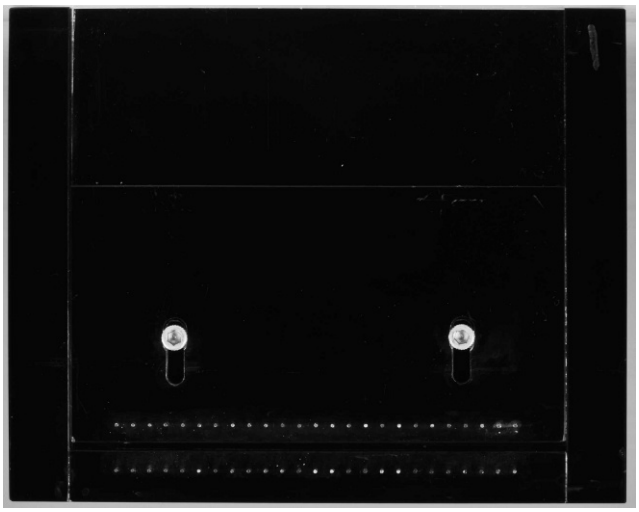

Figure 1. Jig board with 25 sets of pins placed 15 mm apart. Two jig boards were used for this study. These boards had been used in a previous study.[2]

As in the study by Wang et al.,[8] the term *force degradation* has been used in the orthodontic literature. *Stress relaxation* is the technically correct engineering term.[11] Relaxation, however, can be a result of degradation. Because force is being measured, *force decay* is the term used herein to describe this viscoelastic behavior.

MATERIALS AND METHODS

This study was designed to observe the effects of pH levels in artificial saliva on force decay in elastics. Two jig boards (Figures 1 and 2), each with 25 pairs of pins set 15 mm apart, were used to test 30 sets of elastics at a time.

Three groups of 3/16 inch (4.76 mm), 6 oz (184 g) interarch elastics, two nonlatex groups (American Orthodontics, Sheboygan, Wis; Auradonics Inc, Riverside, NJ), and a latex quasi-control group (American Orthodontics) were tested at three pH levels over four time points, with a sample size of 10 in each treatment combination. Latex was included for material comparison. Based on a previous study,[2] the elastics were stretched to 25 mm for force measurement.

Artificial saliva solutions (SOP L021 preparation of synthetic saliva) set at prescribed pH levels of 5.0, 6.0, and 7.5 were provided by the Oral Health Research Institute in Indianapolis, Indiana. pH levels were measured every hour using a calibrated pH/ion meter (Fisher Scientific Accumet Research AR25 Dual Channel, Fisher Scientific, Pittsburgh, Pa) and were adjusted accordingly with 1 M citric acid or 1 M sodium hydroxide. Solutions were incubated at approximately 37°C. The tubs of artificial saliva solution were placed on a rocker (Infors HT shaker AG Model CH 4103, Infors HT, Bottmingen, Switzerland) oscillating between 25 and 50 rpm during the experiment to help maintain a uniform pH.

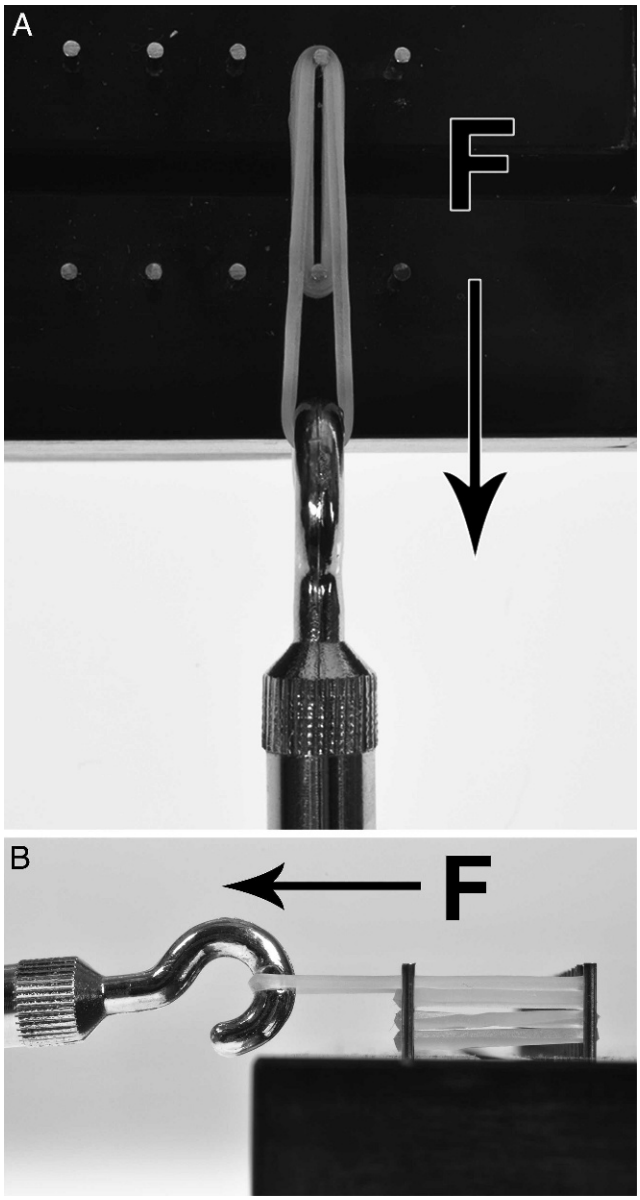

Figure 2. (A) Top and (B) side views of four elastics stacked on 15 mm separated pins. Upon sighting of the hook even with the edge of the board, one of the elastics is being stretched an additional 10 mm. The magnitude of the required force, F, is measured.

Using 10 elastics per treatment combination allowed three groups to be tested simultaneously at the same pH level at 10 seconds (to account for initial stress relaxation), 4 hours, 8 hours, and 12 hours. The force was recorded off a horizontally secured and calibrated digital force gauge (Lutron FG-5000; accuracy ± [0.4% + 1 digit]; Lutron Electronic Enterprise Co Ltd, Taipei, Taiwan) once a consistent reading was established, usually within 4 to 5 seconds.

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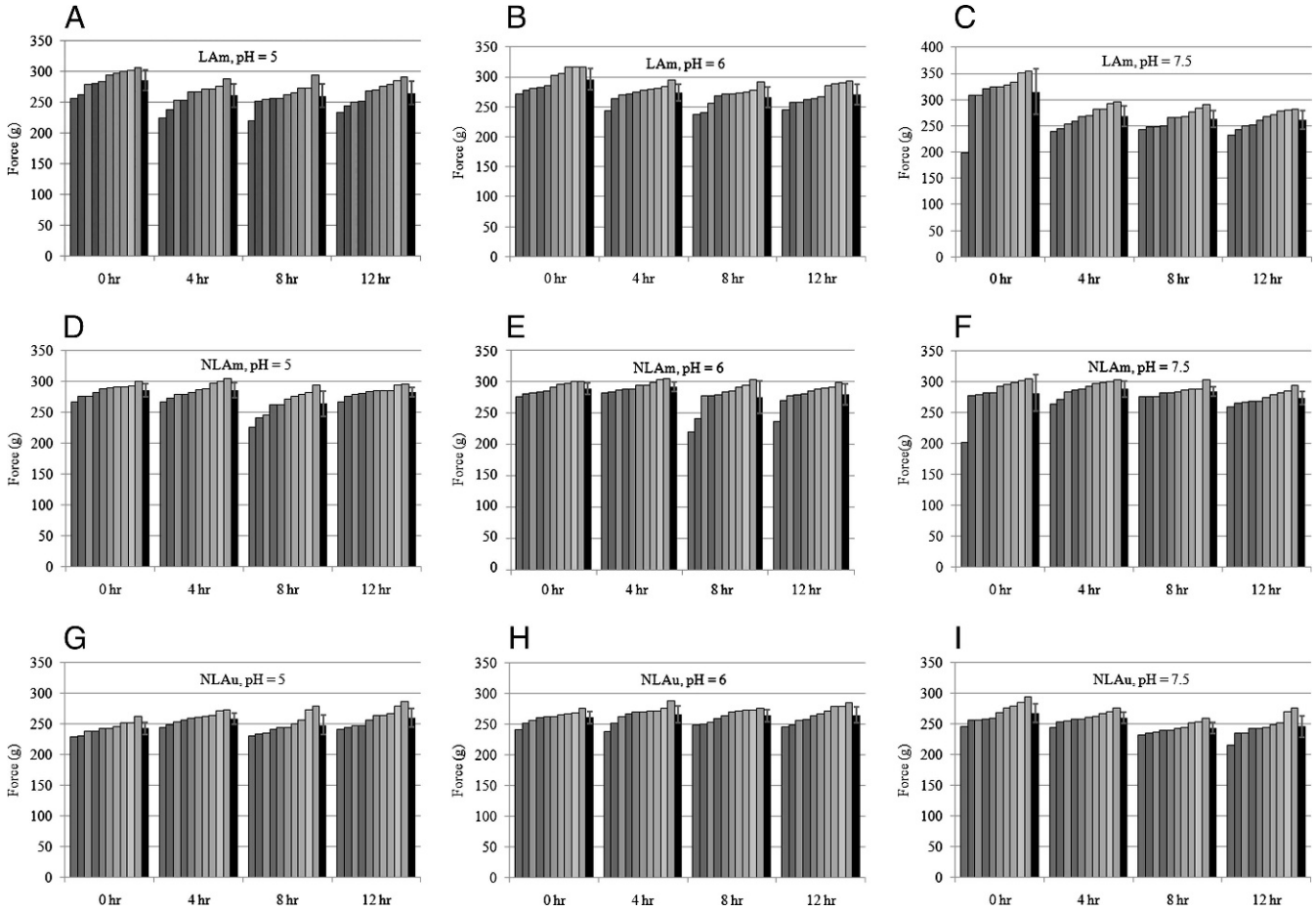

Figure 3. Force measurements, with each bar representing individual specimens, and group means with standard deviations. LAm indicates Latex by American Orthodontics; NLAm, nonlatex by American Orthodontics; and NLAu, nonlatex by Auradonics Inc. No significant correlation was noted between pH and force over time among all products tested. LAm at time point 0, pH 7.5, shows greater variability, which may have been due to inconsistencies in material composition and dimension.

The elastics were randomly selected from different packs of the same type/brand and were appropriately distributed. The tester was blinded as to which type of elastic was on each dowel pin. Figure 2 displays four elastics seated on the pin set, one for each time point measurement.

Statistical Analysis

The standard deviation of the load measurements was estimated to be 0.11 N based on the study by Beattie.[2] With a sample size of 10 elastics per treatment combination (total sample size of $3 \times 3 \times 4 \times 10 = 360$ elastics), the study was designed to have at least 80% power to detect a difference of 0.2 N (20 g) between any two treatment combinations, assuming two-sided tests at a 5% significance level for each set of comparisons among treatment combinations.

The effects of material, pH, and time on measured loads were assessed using three-way analysis of variance (ANOVA). Pair-wise comparisons between treatment combinations were adjusted for multiple comparisons using the Sidak method. Because of non-normal distribution of the loads, analyses were performed using the ranks of the measurements.

RESULTS

Three-way interactions between group, pH, and time were not significant ($P = .13$; Figure 3). The group-by-pH interaction also was not significant ($P = .70$). However, the pH-by-time ($P = .0179$) and group-by-time ($P = .0001$) interactions were significant, so the results for each effect must be conditioned on other effects.

American Orthodontics nonlatex (NLAm) produced significantly higher forces than Auradonics nonlatex (NLAu). NLAm had significantly higher force measurements than LAm at 4, 8, and 12 hours, but not at 10 seconds. LAm readings were significantly higher than those of NLAu at 10 seconds, but not at 4, 8, and 12 hours.

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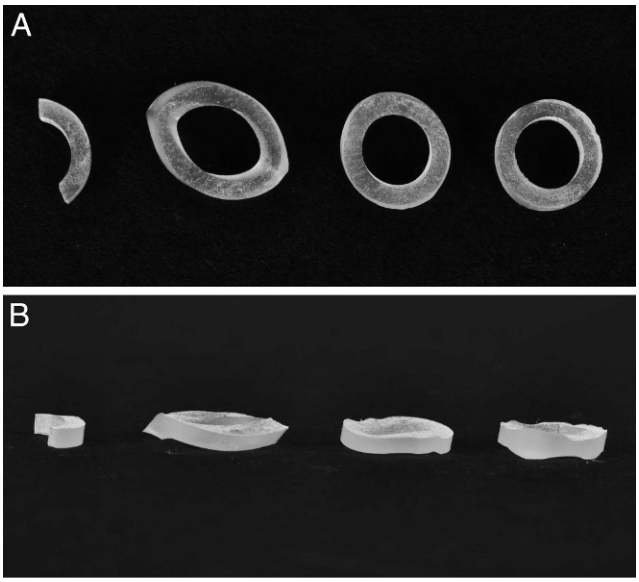

Figure 4. (A) Top and (B) side views of representative latex quasi-control (American Orthodontics) specimens.

At 10 seconds, measurements in pH = 5.0 were significantly lower than in pH = 7.5, although the levels were within the range of all other groups. No other significant differences between pH levels were found.

LAm produced significantly higher forces at 10 seconds than at 4, 8, and 12 hours. NLAm was significantly stronger at 10 seconds and 4 hours than at 8 hours. NLAu did not exhibit a significant time effect (P = .21). When all three groups were combined, significantly higher forces were observed at 10 seconds than at 8 hours for pH = 5.0 and pH = 6.0. For pH = 7.5, forces at 10 seconds were significantly greater than those at 4 hours, 8 hours, and 12 hours.

DISCUSSION

Various studies[2,3,5–9,3,14,17–20] have attempted to establish the mechanical and environmental factors that contribute to the force decay of interarch elastics. However, a recent study[18] involving the effects of pH levels did not consider interarch elastics, nor the material modifications of the past 20 years.[9]

In the present study, pH is not a significant contributor to force decay. Over the 12-hour span of the experiment, time appeared to be influential, with latex elastics exhibiting a marked decrease in force within the first 4 hours, regardless of pH, although a nonsignificant decrease was found in the nonlatex groups. The rapid decrease in force is consistent with most studies in the literature.

During the experiment, factors such as temperature of the artificial saliva, time in solution, and deformations during handling on the jig board were kept as consistent as possible. Nonetheless, as in other studies,[6,7,14] a high level of variability was noted, leading to questions about uniformity in composition and dimension, regardless of brand. Indeed, unmagnified examination of the three products revealed obvious quality control issues in thickness and uniformity (Figures 4 through 6), which the authors believe contributed greatly to variability in force measurements. Future studies have been suggested to examine the manufacturing challenges and lack of consistency among interarch elastics. Such issues should be addressed before additional studies involving variables such as mechanical load, pH, or other contributing factors are undertaken.

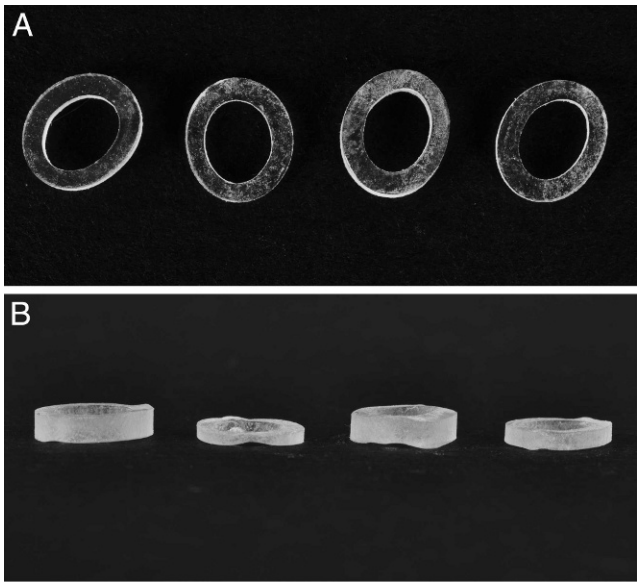

Figure 5. As in Figure 4, but for nonlatex (American Orthodontics).

CONCLUSIONS

- No significant correlation between pH and force decay was observed.

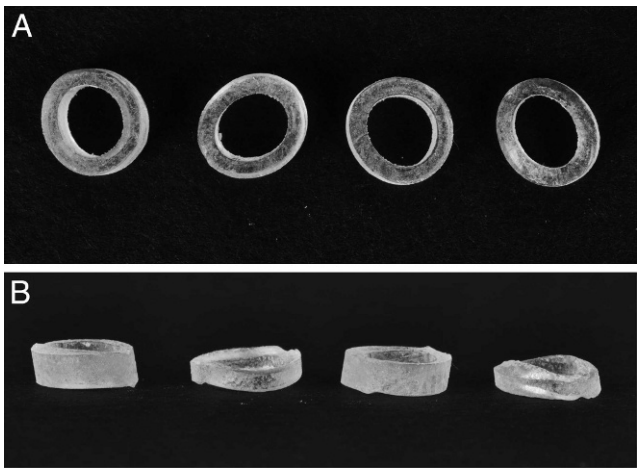

Figure 6. As in Figure 4, but for nonlatex (Auradonics Inc).

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- Time in service and visible imperfections are more influential. Variation in size and quality between specimens within each product probably contributed to the large variability in results.
- Greater consistency in product sizing, thickness, and uniformity is necessary for the conduct of studies into the behaviors of nonlatex and latex interarch elastics.

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