Force degradation of orthodontic latex elastics: An in-vivo study

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Introduction: Our objectives were to assess the force degradation of orthodontic latex elastics over 48 hours in vivo and to study the relationship between the amount of mouth opening and the degree of force decay. **Methods:** Fifty-two orthodontic patients wearing fixed appliances using Class II elastics were asked to wear premeasured-force 3/16-in heavy and medium intermaxillary elastics. The force amounts were measured and compared at different time intervals. **Results:** Fifty percent of the force was lost after 3.9 hours for the medium elastics and after 4.9 hours for the heavy elastics. A continuous significant force drop in all elastics was seen at all time intervals ($P < 0.05$, $P < 0.001$). There was greater force loss in the heavy elastics compared with the medium elastics in vivo at all time intervals ($P < 0.001$); the rates of force loss, however, were similar. **Conclusions:** Fifty percent of force degradation occurred in the first 4 to 5 hours. Because of breakage and for oral hygiene purposes, orthodontic elastics should be changed daily; otherwise, elastics can be used for 48 hours. Force decay of the elastics was correlated to the lateral distance between the maxillary canine and the mandibular first molar in occlusion. (Am J Orthod Dentofacial Orthop 2017;151:507-12)

The use of elastics in orthodontics was introduced about a century ago.[1,2] Elastics are considered an essential part of any orthodontic practice.[3] Latex elastics are characterized by high flexibility, relatively enduring forces, and low cost. Additionally, their use is easy for patients; they can change the elastics by themselves and maintain good oral hygiene while wearing them.[4-6]

Force-extension characteristics and force degradation properties of latex elastics have been reported.[7-11] Several factors may influence force degradation including lumen size of the elastics, saliva environment, PH, and thermocycling.[4,6,12,13]

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Mechanical degradation effects are thought to be the primary cause for force degradation of orthodontic elastic bands during clinical use.[6,9,14,15] It was reported that rubber elastics in a watery or oral environment lose 10% to 40% of their initial force after 30 minutes to 24 hours after they are applied.[11,15] As a consequence of these observations, Andreasen and Bishara[16] suggested using 40% more force than optimal at the commencement of elastic application to compensate for the initial loss. Gangurde et al[6] suggested that the elastics did not need to be replaced so frequently by the patient because, after the initial degradation, the force may remain relatively constant for a few days.

Most force degradation studies were ex vivo, in which the experimental conditions could be controlled, and the results were also reproducible.[6,8,9,11] However, the ex-vivo approach for assessment of mechanical performance of biomaterials has been proven to underestimate the extent and severity of effects induced during intraoral aging of these materials.[17] A few studies have been carried out in vivo to evaluate force decay in elastomeric chains.[18] To our knowledge, no in-vivo studies have investigated force degradation in orthodontic latex elastics at several time points except for a pilot study conducted with a small sample size and a study comparing latex-containing and nonlatex-containing elastics at only few time points.[4,19] Accordingly, the aim of this study was to assess the force degradation of latex elastics longitudinally over 48 hours in vivo.

MATERIAL AND METHODS

Fifty-two orthodontic patients (40 female, 12 male) between 14 and 27 years of age (mean, 20.7 years; SD, ±3.5 years) treated at the orthodontic clinics of the Dental Teaching Clinics, Faculty of Dentistry, at Jordan University of Science and Technology in Irbid, Jordan, participated in this study.

The patients wore straight-wire fixed appliances (Omni Arch; GAC, Bohemia, NY) with Roth prescription (0.022-in slot). The patients used Class II elastics on 0.019 × 0.025 stainless steel wires as part of their treatment. This study was approved by the institutional research board of Jordan University of Science and Technology (approval number IRB/12/300).

For each participant, the following measurements were made.

1. Distance from the maxillary canine to the mandibular molar on the same side in centric occlusion (DCO). The measurement was performed from the cusp tip of the maxillary canine to the tip of the mesiobuccal cusp of the mandibular first molar.
2. Maximum mouth opening measured from the incisal edge of the maxillary central incisors to the incisal edge of the mandibular central incisors (MMO).
3. The distance from the cusp tip of the maxillary canine to the mesiobuccal cusp of the mandibular first molar on the same side in maximum mouth opening (MMOLat).
4. The rubber bands' breakage rates over time and their color changes.

A millimetric stainless steel ruler (Moyoko/Union Broach; Endo Ruler, Montgomeryville, Pa) was used to measure these distances to the nearest 0.5 mm.

Samples of medium (4 oz) and heavy (6 oz) force elastics with 3/16″ diameter (3M Unitek, Monrovia, Calif) were used in this study by each participant. All elastics had recent manufacturing dates and were stored in sealed plastic packages in a cool and dark environment according to the manufacturer's instructions.

A set of 7 tubes contained the premeasured medium elastics. Each tube was marked with the patient's name, type of elastic, and one of the following time intervals: 1, 3, 6, 12, 18, 24, or 48 hours. A similar set of 7 tubes with heavy elastics was also distributed to all participants.

The participants were instructed to wear the elastics according to the assigned intervals marked on the tubes. After the end of each interval, they were instructed to put the elastic back in its tube. The tubes were collected within 2 to 3 hours at most. The force delivered by the elastics was then remeasured 3 times, and the mean of the 3 readings was recorded.

Before each elastic was worn by the patients, the force delivered by the elastic was measured 3 times using a force gauge (Federwaage, bis 1000-g dial-type, stress and tension gauge; Dentaurum, Pforzheim, Germany). Mean force of the 3 readings was recorded. To measure the force, each elastic was stretched with the force gauge from a 1.5-mm thick pin fixed on a custom-made acrylic base with a ruler on the side to determine the stretching distance. A groove was made along the ruler to facilitate stretching the elastics with accuracy. The elastics for each patient were stretched the same distance as measured intraorally from the tip of the canine to the tip of the first molar in centric occlusion of each participant.

A pilot study was conducted on 10 participants before this study. The participants were given elastics to wear for 24 hours, 1 on the right side and 1 on the left. The force losses were measured on both sides and compared (using the Student *t* test for independent samples). No difference ($P = 0.33$) was recorded between the right and left sides. Accordingly, the participants were instructed to wear the experimental elastics on the right side only. All participants received extra similar elastics to wear on the left side according to their orthodontists' recommendation.

Sixty elastics (30 medium, 30 heavy) were randomly selected from the elastic bags and measured 3 times, and the mean reading was recorded. The same elastics were remeasured according to the same procedure after 3 weeks. The elastics were stored in a sealed package in a dark and cool environment as recommended by the manufacturer during these 3 weeks.

Dahlberg's formula[20] for the double measurement error was used to calculate the standard error of the method ($S = \sqrt{\sum (d1 - d2)^2 / 2n}$) and Houston's coefficient of reliability[21] was calculated. The Dahlberg errors were 5.02 cN for the heavy elastics and 3.63 cN for the medium elastics, with reliability above 95%.

Statistical analysis

Data analysis was carried out using the Statistical Package for Social Science computer software (version 17.0; SPSS, Chicago, Ill).

Descriptive statistics were used (means, standard deviations, and percentages of force loss). A general linear model with repeated-measures analysis was used to investigate the effects of time, extension distance, and type of elastics. One-way analysis of variance was used to compare the amounts of force degradation between