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Original Article

Dentistry Section

Influence of Storage Temperature on Orthodontic Elastics

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ABSTRACT

Introduction: Orthodontic elastics are a very significant tool in orthodontics, as it is the most commonly used force delivering unit. Temperature plays a key role in the amount of force that elastics are able to produce. Hence, there is a need to evaluate the influence of storage temperature on the properties of orthodontic elastics before its clinical use.

Aim: To evaluate the influence of different storage temperature of latex orthodontic elastics.

Materials and Methods: This cross-sectional study was conducted at Sathyabama Dental College and Hospital, Chennai, in November 2019. Sample of 40 latex orthodontic elastics (TP Orthodontics, medium force, standard size of 3/16″) were divided into four groups with 10 elastics each, based on their storage temperature and stored in closed plastic packages. Group 1 was kept as a Control group and Group 2, Group 3 and Group 4 were stored in three Incubators under the specified storage temperatures such as 26-28°C, 4-8°C, 37°C respectively. The elastics were stretched and their forces measured in six progressive increases of 100% of their inner diameter, starting at a level of 100% stretching, with the Universal Testing Machine, Instron. The samples were also tested for Maximum Stress (MPa), Maximum Force (N), Maximum Elongation (%) and Break Distance (mm). Data were analysed using Statistical Package for the Social Science (SPSS) software version 16.0, one-way Analysis of Variance (ANOVA) and post-hoc test.

Results: On evaluating the stress at 100%, 200%, 300%, 400%, 500%, 600% of strain, there was no statistically significant difference between the groups. Maximum Stress MPa was found to be 24.12±3.32, 25.12±3.42, 23.3±3.41, 23.97±3.50 for group1, group 2, group 3 and group 4 respectively. Maximum Elongation (%) was found to be 1369.0±25.108, 1364.0±23.190, 1359.0±35.103, 1363.0±34.657 for group 1, group 2, group 3 and group 4, respectively. Break Distance (mm) was found to be 68.48±1.267, 68.28±1.267, 67.87±1.77 and 68.19±1.727 for group1, group 2, group 3 and group 4, respectively. And none of the parameters tested showed statistical significance between the four groups.

Conclusion: Latex elastics may be stored under any of the conditions tested in the present study over a period of one month, since different storage temperatures over a period of one month did not interfere in their mechanical properties.

Keywords: Break, Elongation, Stress, Strain

INTRODUCTION

The latex elastics have become integral part of orthodontics after being first discussed by Calvin Suveril Case in 1893 at the Columbia dental congress. However, the credit goes to Henry A. Baker for the use of these elastics in clinical practice to exert a class II intermaxillary forces [1,2]. The use of latex elastics in clinical practice is predicted on force extension values given by the manufactures for different sizes of elastics. Manufacturers standardise the classification of elastics by internal diameter as 1/8”, 3/16”, and 5/16”, and by force released by 180 g, 170 g, and 184.27 g, respectively [3,4]. Force corresponds to the stretching of elastics by three times their internal diameter [5]. The standard force index employed by suppliers indicates that at three times the original lumen size, elastics will exert the force stated on the package [6].

There are several factors that influence the mechanical properties of elastics, such as the material of the different makes, the influence of saliva, pH, pigments, light, heat, humidity, diet of the individual user, as well as the effects of jaw movements on the structural relaxation [7-9]. An elastic material may suffer a plastic deformation if either subjected to excessive forces or exposed to adverse weather conditions. Elastics are also sensitive to long-term water exposure, enzymes, and temperature variations, and lose part of the force released throughout the stretching period [10-12].

In a previous study by Gonzaga AS et al., the influence of long-term storage on orthodontic elastics was evaluated. The elastics were stretched and their forces measured in five progressive increases of 100% of their inner diameter, starting at a level of 200% stretching. It was concluded that elastics may be stored under any of the conditions tested in the present study, since there were no changes in the potential of the force exerted by the elastics in relation to their percentage stretch over a one year period [13].

Despite the knowledge concerning these orthodontic elastics, there is a lack of confirmative evidences regarding possible changes that could take place in their mechanical properties such as maximum force, maximum stress, maximum elongation, break distance when stored under different conditions for long periods of time. Moreover, intraoral latex elastics are used to help orthodontic mechanics in the delivery of force to the teeth to correct sagittal discrepancies or to improve the interdigitation. And, these elastics are given to the patients, who require replacement on a daily basis for a period of 3-4 weeks before his/her orthodontic appointment. But a concern exists with their influence of storage temperature on its mechanical properties during this period. The present study was conducted with the aim to compare the mechanical behaviour of intraoral elastics after 30 days storage at different temperatures.

MATERIALS AND METHODS

A cross-sectional study was conducted at Sathyabama Dental College and Hospital, Chennai in the month of November 2019, to evaluate the influence of temperature on a total sample of 40 Orthodontic elastics (TP Orthodontics, medium force, 3/16 inch). Institutional review board clearance was obtained from Institutional biosafety and ethical committee (120/IRB-IBSEC/SIST).

Sample size calculation: Using n-master Software, with power of 80% on the alpha error 5%, the sample size was obtained at nine per group.

Accordingly, the elastic samples were divided into four groups with 10 elastics each and stored in closed plastic packages.

Group 1: Control group (as received from the manufacturer)

Group 2: Room temperature (26-28°C)

Group 3: 4-8°C to simulate refrigerator temperature

Group 4: 37°C to simulate highest room temperature in Tamil Nadu.

The criteria used to divide the groups were based on the type of the material storage temperature. The samples remained for a period of 30 days. Incubator (Generic Electric Electronics) was used in this study to regulate the temperature for Group 2 (26-28°C), Group 3 (4-8°C) and Group 4 (37°C). Air sealed plastic bags were used to prevent moisture contamination during storage. The samples were subjected to mechanical testing with the universal testing machine, Instron, at Anna University, Chennai. The removal of elastics from their plastic storage packages and hooking onto the testing machine was made with tweezers without causing any pressure. The universal testing machine measured the force exerted by the elastics. An upper and a lower fixed hook were attached to the machine to hold the elastics for the force tests [Table/Fig-1]. The force required for the test was obtained by means of a 50 N load cell and the machine was set at an operating speed of 100 mm/min.

The mechanical tests were carried out in an increasing order of force. Initially the elastic was stretched to 100% of its initial internal diameter, without any previous stretching, and the force needed to do this was recorded and then the forces required to stretch the elastic to 200%, 300%, 400%, 500% and 600% of its original internal diameter were immediately measured and recorded [Table/Fig-2,3].

[Table/Fig-1]: Elastics engaged onto the fixed hooks.
[Table/Fig-2]: Stretching of elastics. (Image from left to right)

STATISTICAL ANALYSIS

The descriptive statistics consisted of the average and standard deviation for the forces exerted by the elastics of each manufacturer and their groups. The one-way Analysis of Variance (ANOVA) was used for multiple comparison of means for each elongation percentage. All statistics were performed using SPSS software version 16.0 (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA). Statistical significance was considered to be at $p<0.05$ level.

[Table/Fig-3]: Universal testing machine-instron.

RESULTS

Means and standard deviations of stress released due to progressive stretching of elastics (100%, 200%, 300%, 400%, 500%, 600%) are shown in [Table/Fig-4]. There was no statistically significant difference between the groups. Maximum Stress MPa was found to be 24.12±3.32, 25.12±3.42, 23.3±3.41, 23.97±3.50 for group 1, group 2, group 3 and group 4, respectively. Maximum Elongation (%) was found to be 1369.0±25.108,1364.0±23.190, 1359.0±35.103, 1363.0±34.657 for group 1, group 2, group 3 and group 4, respectively. A 130 break distance (mm) was found to be 68.48±1.267, 68.28±1.267, 67.87±1.77 and 68.19±1.727 for group1, group 2, group 3 and group 4, respectively. None of the parameters exhibited significant difference between the four groups.

Stress at strain (in MPa)	Group 1 Mean±SD	Group 2 Mean±SD	Group 3 Mean±SD	Group 4 Mean±SD	p-value
100%	0.78540± 0.071	0.79640± 0.072	0.82340± 0.075	0.88000± 0.092	0.078
200%	1.1220± 0.079	1.1320± 0.089	1.1420± 0.083	1.1850± 0.122	0.461
300%	1.3540± 0.091	1.3940± 0.102	1.3850± 0.086	1.4490± 0.0134	0.382
400%	1.6240± 0.099	1.6320± 0.112	1.6140± 0.097	1.6820± 0.160	0.470
500%	1.8260± 0.109	1.8370± 0.119	1.8170± 0.106	1.9000± 0.193	0.420
600%	2.0620± 0.102	2.0710± 0.132	2.0220± 0.108	2.0950± 0.207	0.571

[Table/Fig-4]: Means and standard deviations of stress released due to progressive stretching of elastics (100%, 200%, 300%, 400%, 500%, 600%).
p-value <0.05 was considered as statistically significant

DISCUSSION

Mechanotherapy in orthodontics often involves the use of inter-arch elastics to correct sagittal discrepancies or vertical elastics to improve the inter-digitation of teeth [14,15]. As these auxiliaries are replaced on a daily basis by the patient, a concern associated with their use pertains to the mechanical properties of the materials.

There are numerous studies for evaluating the force degradation of orthodontic elastics both in-vivo and in-vitro [16-20]. But, there is a lack of confirmative evidences regarding possible changes that could take place in their mechanical properties when stored under different temperatures for period of 30 days which is to simulate the duration the patient has to handle the elastics before his/her next orthodontic appointment. Hence in the present study, mechanical behaviour of intraoral elastics was investigated after 30 days storage at different temperatures and there was no statistically significant difference.

Clinically the recommended stretch of elastics, is three times their internal diameter, so that they can produce an immediate ideal level of force for use in inter-maxillary mechanics for Class II and III correction [21]. Based on this, the present study conducted

the mechanical tests in an increasing order of force so that during the movements of the mandible, the elastics would release forces related to this stretch range. This was in accordance to the study conducted by Gonzaga AS et al., [13].

There are no reported studies evaluating the Maximum force/stress, maximum elongation and break distance of the elastics after one month of storage. Maximum force/limit indicates the elastic limit that a material can endure without undergoing permanent deformation whereas maximum elongation indicates the ultimate before its rupture. Break distance refers to the distance at which elastics ruptures.

In this study, no statistically significant differences with respect to type of storage applied to the elastics was observed, and the average force exerted by the elastics when measured immediately, i.e., as received from the manufacturers, was equivalent to the average force observed after a period of one month under various storage conditions. Therefore, based on the results presented here, it can be stated that the levels of temperature at which the samples were exposed during storage, were not capable of causing any significant decrease or increase in the forces exerted by the elastics assessed within a one-month period. Latex elastics are usually made up of natural rubber materials, obtained from plants; the chemical structure of natural rubber is 1,4-polyisoprene. And over a period of time have evolved for betterment [22]. The inert behaviour of the elastics submitted to the different forms of storage adopted in this study is most likely a consequence of the advances made by the orthodontic industry in the search for new characteristics to increase the efficiency of elastomeric products. This technology gives more resilience through the reduction of undesirable characteristics, such as the deterioration of their elastic properties due to environmental factors (heat, humidity and light), chemicals, artificial and natural aging.

As far the clinical implications are concerned, this study proves that the patient/doctor can store the latex orthodontic elastics at their domestic temperature wherein the properties of elastics shall remain unchanged.

Limitation(s)

Future studies with larger sample size would result in more accurate results and also only one brand material was used in the present study, comparing with different brands of elastics can be used to evaluate the influence of humidity on the mechanical properties of elastics.

CONCLUSION(S)

Latex elastics may be stored under any of the conditions tested in the present study over a period of one month, since different storage temperatures over a period of one month did not interfere in their mechanical properties.

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