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Force Decay of Various Brands of Elastomeric Ligatures: A Longitudinal Study

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Abstract:-

Aim: Evaluation of the force decay of three different brands of elastomeric ligatures

Materials and methods: Sixteen patients undergoing fixed orthodontic treatment were a part of this study. The clear elastomeric ligature modules supplied by three different manufacturers formed the three study groups. The modules were applied with 19 * 25 SS wires in place. Each elastomeric module was placed in the patient's mouth on the specified lower incisor brackets and the force levels were calculated before placement, at 24 hours after placement, 7 days and 21 days after the placement of the modules using a universal testing machine.

Results: Group II elastomeric ligatures exhibited highest mean force levels followed by Group I and Group III. significant difference was observed between the three groups at all the time intervals.

Conclusions: Group II exhibited significantly high mean force levels at all the time intervals that were tested followed by group I and Group III. Group II elastomeric ligatures exhibited markedly less percentage of decay rate in force applied when compared to Group I and Group III

I. INTRODUCTION

Tooth movement is the core of orthodontic treatment. During orthodontic tooth movement, light and continuous forces are desirable for optimum tissue response and rapid tooth movement.[1]Clinicians may use pins, stainless steel ligature; self ligating clips and circular elastomers to ligate orthodontic archwires to the brackets.Elastomeric ligatures are most generally used by clinicians due to their numerous advantages counting low cost, easy application, condensed chair time, patient comfort and gratification.These ligatures are manufactured by many companies in a diversity of different colors that meet the growing global demand for esthetic orthodontic appliances.The force exerted by an elastomeric ligature appears dependent on the magnitude of the initial force, the duration that the force may be applied, and the decay rate of the ligature. The clinician has control over the initial force with the selection of the appropriate sized ligature for the clinical situation and the duration of use.[3]

II. HISTORY

The term "elastomer" states to any member of a class of polymeric materials with the ability to regain shape after deformation. The first common elastomer was natural rubber, probably used by the Maya and Inca civilizations. However, its use was limited due to its physical properties, such as water absorption and thermal instability. In 1920, petrochemical industries began to manufacture synthetic rubber bands, which were adopted by orthodontists in the 60's. With the arrival of vulcanization, introduced by Charles Goodyear in 1839, the physical properties of rubbers were enhanced, significantly increasing its use.[4]

Credit for promoting the use of elastomeric materials in orthodontics goes to forerunners of the mid-18th century, such as Henry Baker, Calvin Case, and Edward H. Angle. Various authors in that era, such as Strange, Tomes, Schange, and Farrar, also advocated the use of natural rubber for orthodontic tooth movement.[5]

III. SAMPLE SIZE CALCULATION

Using the formula,

$$n = \frac{2(SD)^2(Z1-\alpha/2 + Z\beta)^2}{(d)^2}$$

Where, SD = STANDARD DEVIATION- 11.2

$Z1-\alpha/2$ = 1.96 AT 95% CONFIDENCE INTERVAL

$Z\beta$ = 0.84 AT 80% power

d = MEAN DIFFERNCE - 11.1

SUBSTITUITING THE VALUES, WE GET

n = 15.9

Therefore the total sample size is 16.

IV. STATISTICAL ANALYSIS

All statistical analysis were performed by using the SPSS software.

The mean and the standard deviation was calculated for each variable.

Analysis of the data between groups was carried out by 2- way analysis of variance (ANOVA).

$P < 0.05$ was considered as statistically significant.

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V. METHODOLOGY

Sixteen patients undergoing fixed orthodontic treatment and who gave written consent were included in the study. Patients undergoing treatment with MBT prescription, 0.022" slot preadjusted edgewise stainless-steel brackets with aligning and levelling completed and 0.019" x 0.025" SS arch wire placed passively in the lower arch were selected. The clear elastomeric ligature modules supplied by three different manufacturers formed the three study groups.
Group I: Alastik (3M Unitek, USA)
Group II: Molded "O" (Ormco, USA),
Group III: Uni-stick (American Orthodontics, USA)

The elastomeric ligatures were bought from a batch with an optimum shelf life and were stored in a cool dry place until used. The modules remained sealed in their plastic pouches they were placed in the patient's mouth.

Each elastomeric module was placed in the patient's mouth on the specified lower incisor brackets (Group I – Lower left lateral incisor, Group II – Lower left central incisor & Group III – Lower right central incisor) in a conventional figure of 'O' pattern with utmost care. The modules belonging to each group were evaluated at 4 different time intervals at 0 hour (as received), 24, 7 days, and 21 days after intra-oral use. Samples belonging to each group from the 16 patients were retrieved after the specific time interval. The samples were rinsed with distilled water to remove the loosely bound deposits. They were grouped and stored in labeled sterile containers with distilled water and transported to the laboratory and subjected to testing within a time span of 3 hours. An Instron universal testing machine (Instron model 1112, Instron Corp.) was used for this study. The modules were placed between the hooks and stretched to a predetermined length.

Pic. 1: Intraoral photographs showing the different modules placed in the lower incisor brackets during the study period

Pic. 2: Sterile containers were used to transport the samples to the laboratory

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VI. RESULTS

All the three study groups showed significantly high mean force levels as received The elastomeric modules belonging to the Group II recorded a significantly high mean force level at all the four-time intervals tested followed by Group I and Group III.

Table no.1 – Numerical Summaries among 3 groups at various Time Intervals				
Groups	**Total number (n)**	**Minimum**	**Maximum**	**Median value**
Group 1	16			
At 0 hours		635.6	646.8	639.95
At 24 hours		425.6	439.5	433.15
At 7 days		177.5	188.5	181.85
At 21 days		120.2	129.5	124.10
Group 2	16			
At 0 hours		755.2	765.2	761.10
At 24 hours		501.7	511.2	503.45
At 7 days		247.3	256.2	252.75
At 21 days		160.2	169.8	165.35
Group 3	16			
At 0 hours		577.5	587.2	583.05
At 24 hours		371.5	378.2	375.00
At 7 days		162.3	169.8	164.35
At 21 days		114.5	122.5	118.05

Table 1: showing the mean force levels of all the 3 study groups at 4 different intervals of the study

Table no.2 – Intra group comparison at 4 different time intervals among 3 groups (In terms of mean, Standard Deviation and Level of significance) using ANOVA					
Groups	**At 0 hours**	**At 24 hours**	**At 7 days**	**At 21 days**	**P- value**
Group 1	640.5±3.32	433.6±4.38	182.1±3.43	124.9±3.04	< 0.05
Group 2	760.9±2.58	504.9±3.50	252.2±3.00	165.2±2.72	<0.05
Group 3	582.4±3.37	374.7±2.35	165.3±2.63	118.2±2.71	<0.05

Table 2: showing the Intra group comparison at 4 different time intervals among 3 groups. P < 0.05 was considered as statistically significant

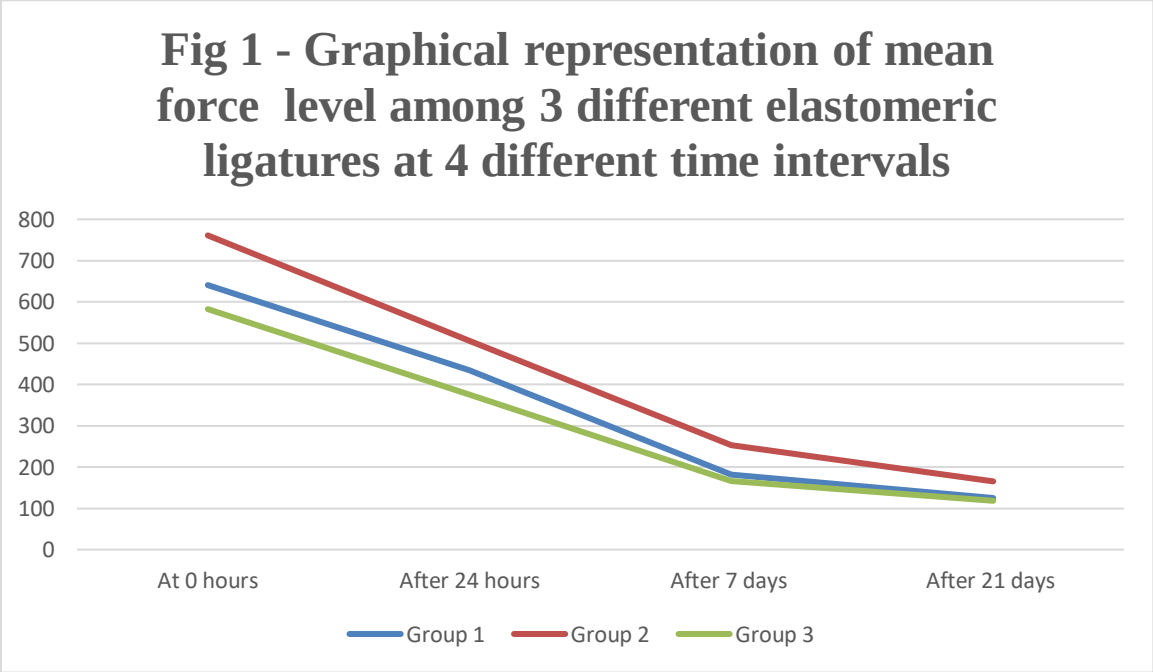

Fig. 1: showing the - Graphical representation of mean force level among 3 different elastomeric ligatures at 4 different time intervals

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Table no.3 – Inter Group comparison at 4 different time intervals among 3 groups (In terms of mean, Standard Deviation and Level of significance) using ANOVA				
Groups	**Group 1**	**Group 2**	**Group 3**	**P- value**
At 0 hours	640.5±3.32	760.9±2.58	582.4±3.37	<0.05
At 24 hours	433.6±4.38	504.9±3.50	374.7±2.35	<0.05
At 7 days	182.1±3.43	252.2±3.00	165.3±2.63	<0.05
At 21 days	124.9±3.04	165.2±2.72	118.2±2.71	<0.05

Table 3: showing the Inter Group comparison at 4 different time intervals among 3 groups. P < 0.05 was considered as statistically significant

Table no.4 – Percentage of force decay of elastomeric ligatures belonging to Group I, II & III			
Duration	Group 1	Group 2	Group 3
0-24 hours	32.31%	33.65%	35.67%
0-7 days	71.6%	66.9%	71.62%
0-21 days	80.5%	78.3%	79.71%

Table 4: showing the Percentage of force decay of elastomeric ligatures belonging to Group I II & III

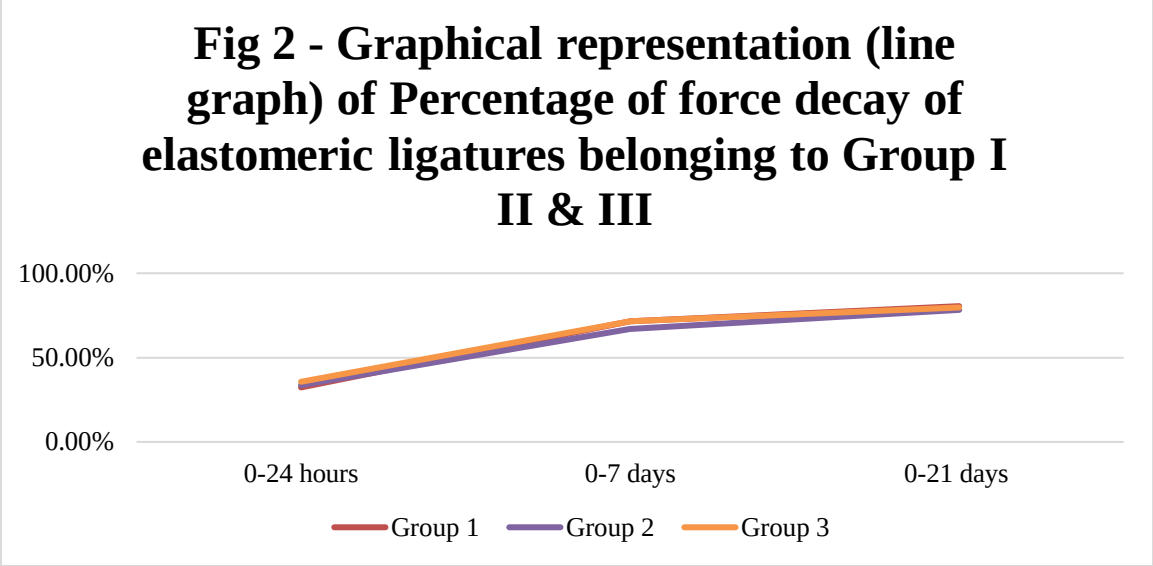

Fig. 2: showing the Graphical representation (line graph) of Percentage of force decay of elastomeric ligatures belonging to Group I II & III

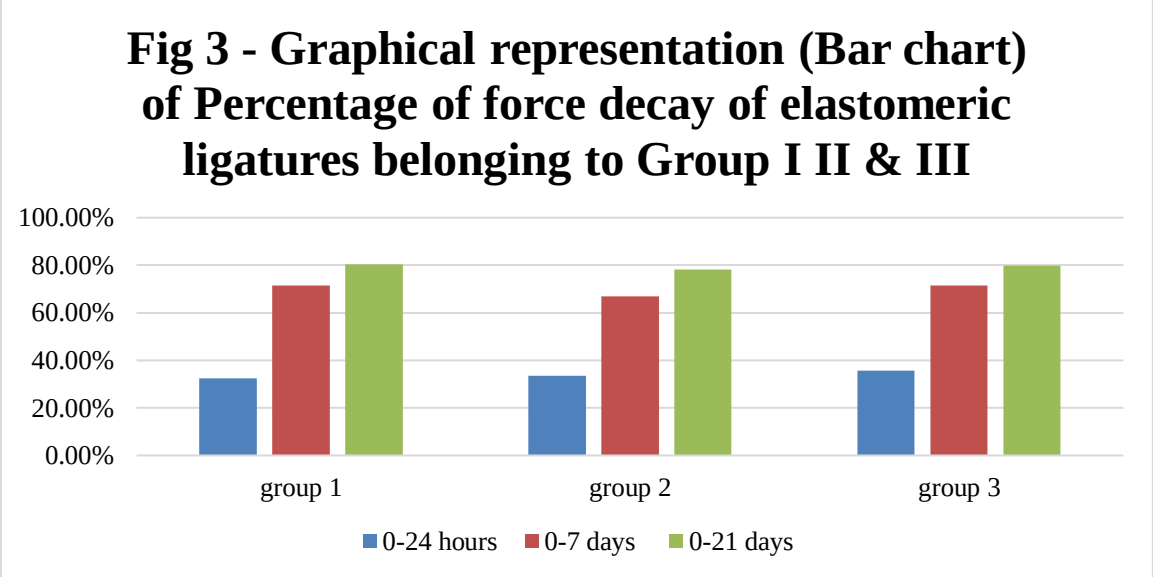

Fig. 3: depicting graphical representation (Bar chart) of Percentage of force decay of elastomeric ligatures belonging to Group I II & III

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Group I showed a percentage force decay of 32.31% in the first 24 hours, 71.6% in the next 7 days and 80.5% in the 21 days of study period. Whereas Group II showed a decay rate of 33.65%, 66.9% and 78.3% at the similar time intervals examined.Group III showed a percentage force decay of 35.67% in first 24 hours, 71.62% at the 7 day time period and 79.71% at the end of the study period.

VII. DISCUSSION

The variation/decay in the force exerted over time by these elastomeric chains inclines to disturb the therapeutic tooth movement. The force decay can be a result of exposure to the intraoral environment, mastication, level of oral hygiene, salivary enzyme activity, and variations in oral temperature. Therefore, various authors have researched force decay and described that maximum force loss occurs during the initial days, followed by mounting force decay during subsequent days/weeks. Improper seating of wore in bracket and loss of retraction force are main consequences of force decay.Assessment of the mean force calculation over the 3 different time intervals aided us to conclude that Group II showed highest force levels at all the time intervals of measurement followed by Group I and Group III. Elastomeric materials are altered in the presence of moisture by water sorption that facilitates slippage of molecules or polymer chains past one another accelerating the force decay process. Most of the decay in force occurred within the first day and continued at a slower rate during the rest of the three week period. The assessment of percentage of force decay showed that at the time interval of 24 hours, force decay was highest in Group III followed by Group II and Group I. At the end of 7 days it was highest in Group III followed by Group I and Group II and the end of the study period it was highest in Group I followed by Group III and Group II The results of this study give the clinicianadditional information to make choices about productsthey use. The virtual reality, when it comes toselecting elastomeric ligatures, may be the clinician'sloyalty to a particular company, cost of theligatures, the diversity of sizes and colors availableand possibly, the clinical feel of the ligatures. Thisarticle presents other reasons to consider whenselecting elastomeric ligatures such as dimensional stability, forces generated, and force decay.

VIII. CONCLUSIONS

- Group II exhibited significantly high mean force levels at all the time intervals that were tested followed by group I and Group III
- Force exerted by elastomeric ligatures were different at different time intervals of the study.
- Group II elastomeric ligatures exhibited markedly less percentage of decay rate in force applied when compared to Group I and Group III
- Forces that elastomeric ligatures exert on fully engaged arch wires are not as high as those for stainless steel ties. Elastomeric ligatures exert excessive initial force levels well above the optimal recommended force levels.
- Elastomeric ligatures lose considerable force at the end of day 1 and at the end of the 1st week, with the maximum loss occurring in the first hour.
- The variation/decay in the force exerted over time by these elastomeric chains tends to affect the therapeutic tooth movement.
- The force decay can be a result of exposure to the intraoral environment, mastication, level of oral hygiene, salivary enzyme activity, and variations in oral temperature

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