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Effect of polymer coated elastomeric ligatures versus stainless steel ligatures on retraction rate in pre-adjusted edgewise therapy

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Abstract
Friction produced during sliding mechanics tends interfere with orthodontic tooth movement and compromise the treatment result. Various ligation materials and techniques have been introduced to reduce the friction at the bracket-archwire interface. One of the new ligature materials introduced is super slick ligatures. The present study was done to assess the effectiveness on the rate of space closure between polymer coated super slick ligatures and stainless-steel ligatures during en masse retraction in maxillary dentoalveolar protrusion.
Methods: Twenty patients were selected and randomly divided into two groups of ten each. During en masse retraction of maxillary anteriors, the archwire was ligated with super slick ligatures in group 1 and stainless-steel ligatures in group 2. The rate of space closure was measured from study models taken at monthly intervals for six months.
Results: The mean rate of retraction of maxillary anterior teeth was higher with stainless steel ligatures. However, no statistically significant difference was observed between the two groups ($p > 0.05$).
Conclusion: The polymer coated super slick ligatures and stainless-steel ligatures showed no statistically significant difference in en masse retraction of anteriors of maxillary arch. The super slick ligatures can be considered as suitable alternative to stainless steel ligatures during space closure.

Keywords: sliding mechanics, friction, super slick ligatures, stainless steel ligatures

1. Introduction
One of the primary goals in orthodontics is to provide the most efficient tooth movement and this quest has inspired the development of countless materials in orthodontics aimed at increasing patient comfort and reducing treatment time. Treatment mechanics with the pre-adjusted appliance represent an effective method for controlled orthodontic tooth movement. During space closure with sliding mechanics, frictional force generated at the bracket-archwire interface tend to impede the desired tooth movement [1]. Between 12% - 60% of the applied force in fixed appliance is lost by friction and the force applied must overcome this frictional component to achieve the desired movement [2]. By controlling frictional resistance at the bracket-archwire interfaces, lower levels of force can be applied during orthodontic treatment to obtain an optimal biological response for effective tooth movement [3, 4].
A combination of mechanical and chemical factors determines friction at the archwire-bracket-ligature interface. The factors that have been suggested to influence frictional resistance are bracket wire interaction, bracket material and wear of wire, bracket width and inter bracket distance, arch wire material, arch wire diameter and cross sectional shape, wire stiffness, bracket wire angulation, method of ligation, surface roughness of wire, sliding velocity and saliva [5]. The type of ligation employed to secure the archwire to brackets can account for a part of frictional resistance occurring during sliding mechanics. Elastomeric ligatures are believed to exert 50 - 150 gms of force at the time of seating, thereby contributing to friction [2].
Factors, which influence friction featuring both archwire and bracket in terms of size and material have been investigated extensively with respect to frictional force. The role of archwire ligation in the generation of friction has received limited attention in the literature. To reduce frictional force from ligation, various methods have been used such as stainless-steel ligatures and self-ligating brackets. Stainless steel ligatures produce variable ligation forces and are time consuming to place [6]. Self-ligating bracket systems can lead to reduced treatment time and low frictional resistance, but are more costly [7].
Elastomeric ligatures have replaced stainless steel ligatures since their introduction to orthodontics in 1960s. Advantages offered by these modules include quick application and removal, enhanced patient comfort, fluoride release potential and availability in a variety of colors for better patient acceptance. However, their disadvantages are that the dentition and soft tissues may be adversely affected by microbial accumulation on the tooth surface around the bracket ligated.

Ligation material has also evolved with time in an attempt to reduce friction. Some of these materials are slackened stainless steel ligatures, stainless steel ligatures coated with fluorine-containing resins, modified elastomeric modules, super slick ligatures and slide ligatures [8]. One of the non-conventional elastomeric ligatures is 'super slick ligatures' made by TP Orthodontics, created with a hydrophilic coating so that when wetted by saliva the surface becomes slippery. It has a covalently bonded polymer coating to reduce friction, which is manufactured using Metafasix technology. It is an injection moulded polyurethane ligature dipped in a hydrophilic polymer blend of methylene chloride (600g), methyl ethyl ketone(400g) and polyvinyl pyrrolidone (10 g). This coating is then cured by air drying for 10 min and oven baking at 80°C for 20 min[9]. It is available in different colours.

Previous in-vitro studies and a few clinical studies have shown that nonconventional elastomeric ligatures can reduce frictional resistance compared with conventional ligatures, both during initial levelling and aligning, and in the retraction phase of orthodontic treatment. This study was undertaken to assess the efficiency of polymer coated ligation material in reducing friction by comparing the rate of space closure during en-masse retraction of anterior teeth in bimaxillary protrusion patients with stainless steel ligature.

2. Materials and Methods

This prospective observational study was done in the Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College, Thiruvananthapuram.

2.1 Inclusion criteria:

1. Patients with proclination of upper anterior teeth with age 18 years and above.
2. Maxillary arch with well aligned teeth or with crowding.
3. Patients with full set of teeth in maxillary arch.
4. Patients without upper midline shift.

2.2 Exclusion criteria

1. Patients with craniofacial deformity and systemic diseases.
2. Patients having malocclusion requiring extractions other than first premolar.
3. Periodontitis with poor oral hygiene.
4. History of previous orthodontic treatment.

20 patients were selected based on above criteria and the patients were randomly divided in two groups.

- **Group 1 (Polymer coated group):** Consisted of 10 patients (n=10; pretreatment age>18years) who were undergoing fixed orthodontic treatment and retraction of maxillary anteriors by sliding mechanics, ligated with super slick ligatures during retraction.
- **Group 2 (Stainless steel group):** Consisted of 10 patients (n=10; pretreatment age>18years) who were undergoing fixed orthodontic treatment and retraction of maxillary anteriors by sliding mechanics, ligated with stainless steel

2.3 Materials used in the study

- Clear super slick ligatures (TP Orthodontics, LaPorte, Ind) (Fig. 1)
- Stainless steel ligatures of 0.009" diameter (Sendent, Libral Traders, New Delhi, India) (Fig. 2)
- Digital vernier caliper of 0.01 mm sensitivity (Zhart electronics, Rajasthan, India) (Fig. 3)

Fig 1: Super slick ligatures

Fig 2: Stainless steel ligature

Fig 3: Digital vernier caliper

Extractions of all first premolars were completed about 1 week before starting the orthodontic treatment to ensure the patient's comfort. Brackets with 0.022"x0.028" slots with the MBT prescription were bonded. After initial alignment and levelling, maxillary and mandibular study models were made and 0.019" x0.025" posted arch wire were placed for en-masse retraction of anterior teeth. The distance between the central pit of the first molar and the canine tip were measured on the maxillary study model with the digital vernier calliper. This recording was kept as the base reading to evaluate the amount of anterior retraction in subsequent intervals.

In group 1(Polymer coated group), for en-masse retraction of anterior teeth, all brackets were ligated with super slick ligatures in the upper arch (Fig.4). In group 2(Stainless steel group), conventional stainless-steel ligatures were used (Fig.5). The retraction was carried out with NiTi closed coil springs. The patients of both the group were recalled at monthly intervals to make the impression for the study model. The amount of space closure in upper arch for each patient was measured on study

model for 6 months. The rate of retraction is calculated as the amount of extraction space closed divided by the time (6 months) required for space closure. This will be recorded in millimeters per month. There were no drop outs in the study and hence all the 20 samples were used to study the en masse retraction rate of anterior teeth in maxillary arch.

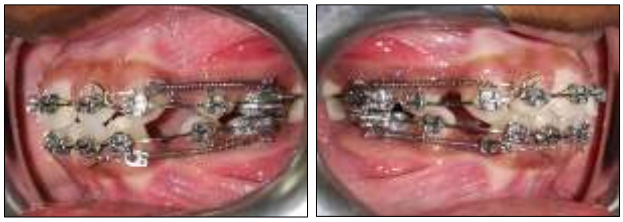


Fig 4: Retraction in super slick group

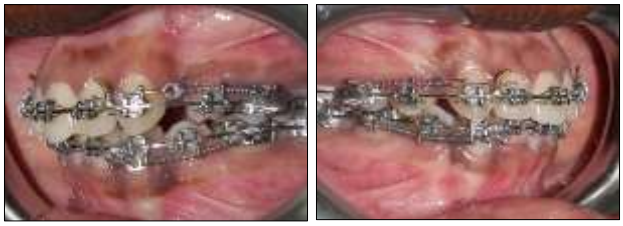


Fig 5: Retraction in stainless steel group

2.4 Statistical Analysis

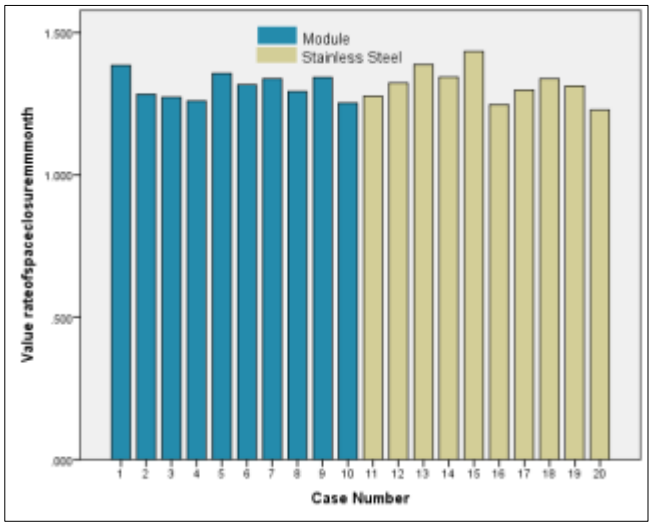
The software employed for statistical analysis of the data was Statistical Package for Social Sciences (SPSS version 16). The independent 't' test was used to compare between two groups.

3. Results

Descriptive statistics were used to assess the amount of retraction of anterior teeth at each monthly interval for 6 months. The statistical comparison of two groups was carried out using parametric test. The mean and standard deviation of rate of space closure of group 1 with polymer coated ligatures and group 2 with stainless steel ligatures were 1.310 ± 0.045 mm/month and 1.319 ± 0.062 mm/month respectively (Table 1). Graph 1 shows the comparison of rate of space closure in mm/month in both the groups. The range in the rate of space closure between polymer coated (group 1) and stainless-steel ligature (group 2) groups were 0.132 mm/month and 0.206 mm/month respectively (Table 2). The difference between mean rates of space closure for groups 1 and 2 was found to be-0.009 (Table 3). The mean difference in the rate of space closure between groups 1 and 2 was -0.051 to 0.051 mm per month with 95% confidence interval (CI) (Table 3 and 4).

Table 1: Descriptive Statistics of rate of space closure in mm/month among the study groups

Groups	N	Minimum	Median	Maximum	Mean	SD
Group 1	10	1.253	1.305	1.385	1.310	0.045
Group 2	10	1.228	1.318	1.434	1.319	0.062



Graph 1: Bar diagram showing comparison between rates of space closure in groups 1 and 2

Table 2: Range of rate of space closure in mm/month among the study groups

Groups	Mean	SD	SEM	Range
Group 1	1.310	0.045	0.014	0.132
Group 2	1.319	0.062	0.020	0.206

Table 3: Difference between mean rates of space closure in mm/month of study groups

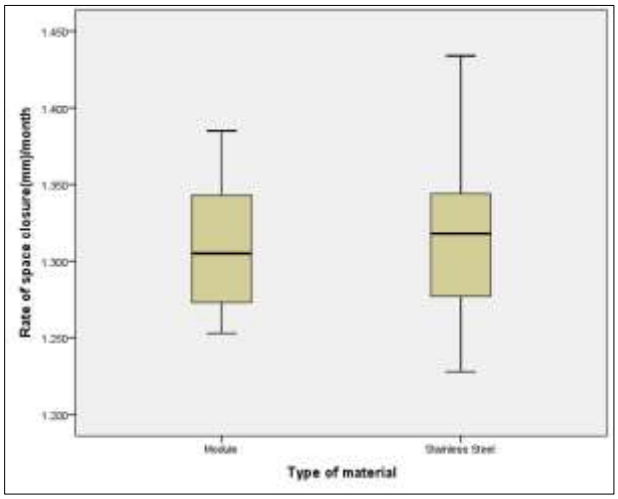
	Mean difference	Std. Error Difference	t	df
Rate of space closure(mm/month)	-0.009	0.024	-0.364	18

Table 4: Confidence intervals and p value for independent samples t test

	95% CI of the difference		Significance (2-tailed)
	Lower	Upper	p value
Rate of space closure(mm/month)	-0.060	0.042	0.720*

***** p > 0.05, not statistically significant

Graph 2 shows comparison of rate of space closure between two groups. It shows that the median of group 1 was 1.305 mm/month with minimum and maximum value of 1.253 mm/month and 1.385 mm/month respectively. The median of group 2 was 1.318 mm/month with minimum and maximum value of 1.228 mm/month and 1.434 mm/month respectively. The interquartile range of group 1 was 0.077 mm/month and for group 2 was 0.086 mm/month respectively. Out of the data entered, most of the values of group 1 and group 2 fall under 4th quartile.



Graph 2: Box Whisker plot showing rates of space closure between study groups

Independent t test was carried out to find whether there was any statistically significant difference between the two groups. The t value was -0.364 with a p value of 0.720($p > 0.05$), indicating no statistically significant difference between the mean rates of space closure of group 1 and group 2.

4. Discussion

In the present study effectiveness of polymer coated super slick ligatures and stainless-steel ligatures were studied by comparing the rates of space closure during en masse retraction of anterior teeth in maxillary arch. Study models were made at monthly intervals to measure the amount of retraction. Only two sets of study models, before and after retraction, would have served to determine the rate of retraction. However, at each interval of patient recall, study models were made to evaluate the amount of retraction of anteriors. This approach was aimed to observe whether there was any particular trend toward change in the rate of tooth movement with time.

In the current study, cusp tip of canine and central pit of the first permanent molar were chosen as the landmarks because they can be reliably located on study models and are closer to the arch wire along which the retraction force is applied. The distance between the distal surface of the canine and the mesial surface of the second premolar was not considered for calculating the rate of retraction, as anchor loss, tipping of canines and premolars and changing gingival contours affect the reliability.

In the present study, the mean retraction rate for group 1 (super slick ligatures) was 1.310 ± 0.045 mm/month with a minimum value of 1.253 mm/month and maximum value of 1.385 mm/month. The mean retraction rate for group 2 (stainless steel ligatures) was 1.319 ± 0.062 mm/month with a minimum value of 1.228 mm/month and maximum value of 1.434 mm/month.

The mean rate of space closure for stainless steel ligatures (1.319 ± 0.062 mm/month) was found to be greater than super slick ligatures. This could be explained by the reduced friction offered by stainless steel ligatures which permits the easy sliding of arch wire through the brackets. This result was similar to a study where stainless-steel ligation produced less friction when compared with elastomeric and self-ligation [10]. In another in vitro study it was found that stainless steel ligatures showed lowest frictional forces when compared with elastomeric ligatures [11].

However, the result of the present study contradicts the result obtained in another study which showed that friction produced by elastomeric module is less than that produced by stainless steel ligatures [12]. Also, in one of the previous study, the steel ligatures produced greater friction than elastomers. Most likely, the lower friction values were the result of the coated ligatures possessing a lower coefficient of friction than the uncoated ligature.

The mean rate of space closure for super slick ligatures obtained was 1.310 ± 0.045 mm/month which was slightly less than that of stainless-steel ligatures which could be attributed to friction between archwire-bracket-ligature interface. This finding was similar to another study in which the frictional forces were found to be greater for superslick ligatures when compared with stainless steel ligatures [13]. The frictional forces of super slick ligatures were also found to be greater than self-ligating brackets [14]. It was found that elastomeric ligature loses elasticity with time and can alter the frictional force values[15].

But in another in vitro study the super slick ligatures produced lower levels of friction when compared to conventional uncoated ligatures [16]. Also, the use of super slick ligatures determined a reduction of friction comparable to self-ligating brackets, where the static friction at the module-archwire interface was reduced to 60% regardless of the bracket system [2].

On comparing the rate of space closure between super slick and stainless-steel ligatures, there was no significant difference between retraction rates of two groups in our study. Thus, the super slick ligatures were found to be a suitable alternative to stainless steel ligatures during retraction phase. In a previous study which compared frictional resistance between elastomeric and steel ligations, it was found that there was no difference between the two ligations, which is in accordance with the present study [16].

In two other in vivo studies where the rate of canine retraction was studied, no significant difference was observed between non-conventional and conventional ligatures [8]. In another study, a statistically significant difference in the rates of canine retraction between elastomeric and stainless-steel ligatures was observed, with the rate of canine retraction higher for the elastomeric ligatures [17]. Also, a significant difference was obtained in another study where the rates of canine retraction between self-ligating brackets and stainless-steel ligatures were compared with canine retraction rate higher for stainless steel ligatures.

One of the limitations of the study is that the study sample was too small to detect a significant difference between the two groups; however, the descriptive data showed that there were very small mean differences in the amount of space closure between the groups. Conventional methods like assessment using alginate impression and study models may not be accurate in measuring the different variables as the distortion of materials are greater. A digital model should have been a better choice to eliminate this bias.

Anchorage loss by mesial movement of molars has not been assessed in this study which is another drawback of the study. So, the distance between molar and canine may not be accurate to assess the amount of incisor retraction. The effects of other factors present in the mouth such as salivary lubrication, shock absorption of the periodontal ligament and stress-breaking effects

during mastication which vary between individuals have also not been considered.

In the present study en masse retraction of anterior teeth was assessed. More investigations are needed to study the clinical efficiency of polymer coated ligatures in rate of canine retraction. The retraction rate was the only parameter compared in the current study. More clinical studies are required to determine other parameters like change in first molar position, rotation and tipping of molars.

5. Conclusions

In this study to assess the rate of space closure in maxillary arch between polymer coated elastomeric ligatures and stainless-steel ligatures, the following conclusions were drawn:

1. The super slick ligature module and stainless-steel ligatures are effective in space closure.
2. The mean rate of space closure for stainless steel ligature group is greater than super slick ligature group.
3. There was no significant difference in the rates of space closure in the maxillary arch between polymer coated elastomeric ligatures and stainless-steel ligatures.
4. The polymer coated super slick ligatures can be a suitable alternative to stainless steel ligatures for retraction of anterior teeth.

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