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Evaluation of tensile strength of different configurations of orthodontic retraction loops for obtaining optimized forces

Miceli Beck Guimaraes Blaya, Graziela Henriques Westphalen, Magali Beck Guimaraes, Luciana Mayumi Hirakata

SUMMARY

The aim of this study was to analyze the mechanical behavior of different orthodontic retraction loops. Two designs of orthodontic loops for closing space were analyzed: teardrop-shaped (T) and circle-shaped loop (C), of two different heights (6 and 8 mm), and two types of orthodontic wires (stainless steel – 0.19' × 0.25'; TMA – titanium molybdenum alloy – 0.016' × 0.016'). The sample consisted of 80 loops, divided into 8 groups determined by the combination shape/height/type of wire, which were submitted to tensile testing at a speed of 2 mm/min., to measure the quantity of force generated when activated in the interval of 0.75 mm and 2.25 mm. The results were submitted to the ANOVA and Tukey statistical tests to compare the groups, and the Student's-*t* test to compare the means of two groups. Statistically higher values were observed for the size 6 mm, circle shape and stainless steel composition. The group "teardrop-8 mm-TMA" together with the group "circle-8 mm-TMA" presented the lowest mean value, differing statistically from all of the other groups. It was concluded that the alloy of the wire and the height of the loop would be more important than the loop design.

Key words: orthodontics, orthodontic loop, retraction.

INTRODUCTION

Since the 1940s, orthodontists, such as Tweed and Strang, in disagreement with the "non extractionist" theory adopted by Angle, began to reco mmend a new treatment alternative within orthodontic planning, including the extraction of teeth [1]. Thus, it was also necessary to develop more effective methods for closing residual spaces resulting from these extractions [2,3,4].

Several orthodontic mechanisms were designed for closing spaces. Among the various devices described, there are many ranges of loops, which may be used, incorporated into continuous or segmented arches, for dental movement. Due to the large number of options, a great deal of attention must be paid when selecting the most appropriate model for each case. In this choice, certain variables must be analyzed, among them the loop design, it quantity of activation, wire thickness, the metal alloy used, type of movement desired and the quantity of force necessary. When using loops for closing spaces, it is of the utmost importance for the professional to determine precisely the system of forces generated; that is, it is important for the orthodontist to know the magnitude of the forces and the moments released when these devices are activated [5].

When used in an improper manner, orthodontic loops for closing spaces could cause unfortunate effects, such as: undesirable loss of anchorage, excessive verticalization of the anterior teeth, root resorbtions, or other. These effects, in addition to increasing the time of treatment, may also cause irreversible damage to patients [6].

Among the advantages of closing spaces with the use of retraction loops is obtaining better control of anchorage, provided by incorporating pre-activation folds of different intensities into the anterior and posterior extremities of the loops, as well as by positioning them in the inter-bracket distances [7].

In this context, three basic properties can be considered for characterizing space closing loops: (1) the proportion moment/force (M/F), which determines the center of dental rotation and thus enables root control during the movement of the teeth; (2) the horizontal force produced during loop activation and (3) the load/deflection ratio, which defines the amount and decrease

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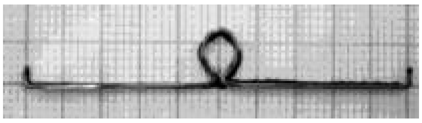

Fig. 1. Demonstration of teardrop loop made on millimetric paper jigs

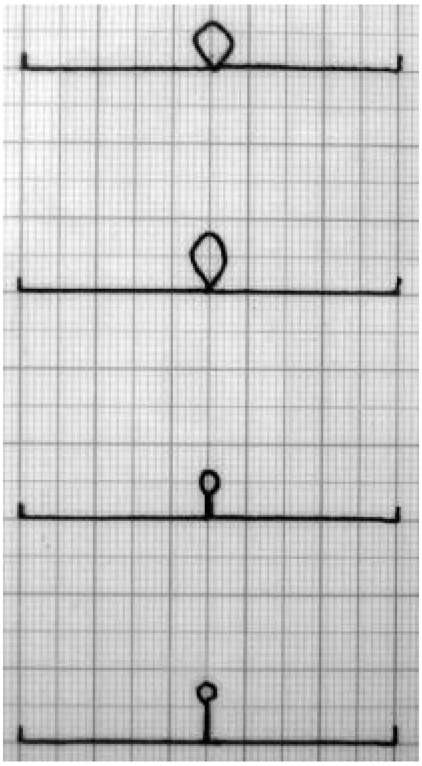

Fig. 2. Demonstration of arches made on millimetric paper jigs

in force at each millimeter of deactivation [8].

Vanderby et al [9] performed an experimental study of vertically activated orthodontic loops. They considered T, L, and rectangular configurations designed for an interbracket distance of 7 mm. The material used was 0.010' × 0.021' stainless steel wires. They suggested that the forces and moments generated by the stainless steel loops were sensitive to small inaccuracies during loop fabrication.

Menghi et al [10] studied R, L e T- loops experimentally with a view to establishing a 3-dimensional description of the force systems delivered by these 3 loop configurations for both stainless steel and titanium molybdenium alloy (TMA) for first-order corrections. All the specimens had nominal cross-sections of 0.017' × 0.025'. The authors concluded that correction of first-order discrepancies was best accomplished using rectangular loops.

More recently, Coimbra et al [11] performed an in vitro study with a mechanical testing and finite element analysis of orthodontic teardrop loop and the results was that the use of teardrop loops of different heights should be considered an alternative for designing orthodontic appliances before treatment.

The aim of this study was to analyze the mechanical behavior under tensile tests, of different shaped retraction loops, various orthodontic wires compositions and widths; and determine, within the variables analyzed, which of them most influence the system of forces.

Table 1. Division of the groups

Group	Shape	Width (mm)	Type of Wire	Sample (n)
G1	T	6	TMA	10
G2	T	8	TMA	10
G3	T	6	Stainless steel	10
G4	T	8	Stainless steel	10
G5	C	6	TMA	10
G6	C	8	TMA	10
G7	C	6	Stainless steel	10
G8	C	8	Stainless steel	10

T– teardrop-shaped loop; C – Circle-shaped loop.

MATERIAL AND METHODS

Two designs of orthodontic loops for closing space were analyzed: teardrop-shaped (T) and circle-shaped loop (C), of two different heights (6 and 8 mm), and two types of orthodontic wires (stainless steel – 0.19' × 0.25'; TMA – titanium molybdenum alloy – 0.016' × 0.016'). The sample consisted of 80 loops, divided into 8 groups determined according to the interaction shape/height/type of wire (Table 1).

In order to uniform the shape and dimension of the loops when making the tests specimens of the same subgroup, jigs were made of millimeter paper (Figures 1 and 2).

The sample was submitted to tensile testing in a universal mechanical test machine EMIC DL 2000 (São José dos Campos, SP, Brazil), at a speed of 2 mm/min, to measure the quantity of force generated with the loops are activated in the interval of 0.75 mm to 2.25 mm. The values obtained were disposed in Tables and Graphs, from which statistical analysis was performed.

The comparison among groups was carried out by using Analysis of Variance (ANOVA) and Tukey's multiple comparison tests. For comparison of the means of the variables height, type of wire and shape, the Student's-*t* test was performed. To process and analyze these data, the statistical software SPSS version 10.0 was used. A level of significance used to determine the differences between the groups were 1%.

RESULTS

It was verified that there was significant difference among the groups compared (ANOVA). By the Tukey's test it was observed that G7 presented a higher mean, differing from all the other groups; G3 came

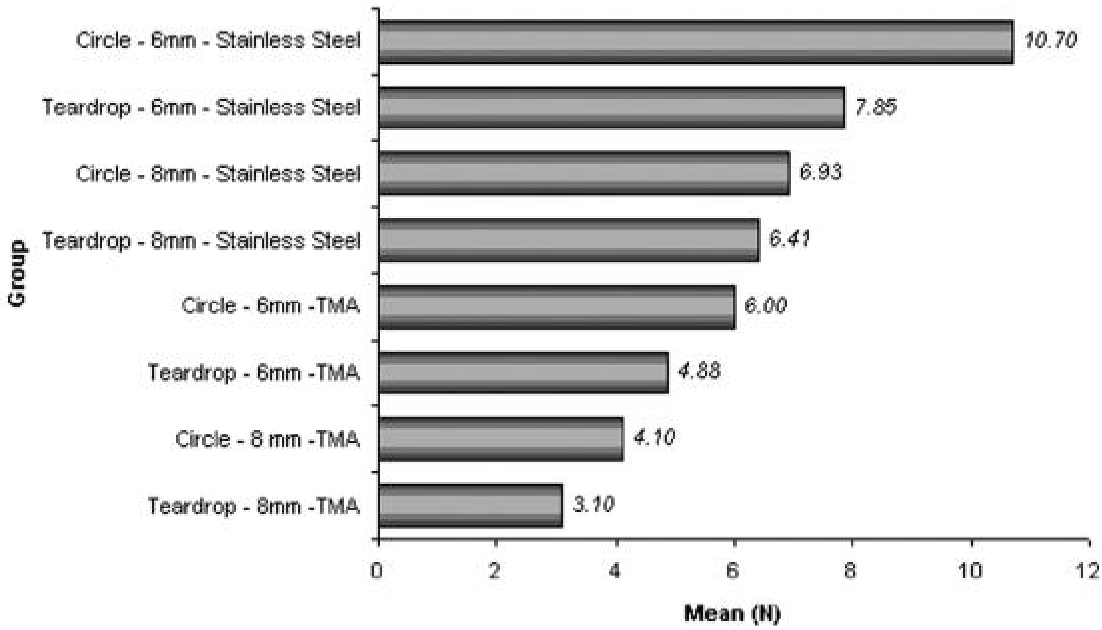

Fig. 3. Results of the comparison among the 8 study groups (in ascending order)

next, and did not differ from G4 and G 8. There was no significant difference between G1 and G5 and between G2 and G6 (Table 1, Figures 3).

The Student's-*t* test revealed statistically significant difference when the variables were analyzed in isolation (Figures 4).

DISCUSSION

In this study, after the mechanical test, the circle-shaped and "teardrop-8 mm-TMA" groups showed the lowest mean values, differing statistically from the groups that were 6 mm high. Although there was no statistical difference when the variable height was evaluated in isolation, in conjunction with other characteristics a lower height could generate greater results, according to this study.

This can be explained if one takes into consideration that changing the metal alloy used for making the loop can alter the load/deflection ratio. Therefore, a loop constituted of an alloy with a low elastic modulus, such as titanium-molybdenum, would have a lower load/deflection ratio than a loop with the same configuration, made of stainless steel [12]. Although the variable alloy of the wire had been evaluated in isolation, and no significant difference had been found, the interaction among the variables of this study show that the wire alloy could influence the results, favoring the application of greater heights to provide smaller forces during the retraction phase of anterior teeth.

For many years, stainless steel was one of the most important materials for orthodontic arches [13]. However, since the early 1960s, researches in the clinical applicability of titanium as a structural metal for the composition of wires began to be conducted. Titanium wires, also known as TMA (Titanium Molybdenum Alloy) because they have approximately 11.3% of molybdenum in their composition, have all the properties of a wire said to be "superior": high elastic recovery, lower rigidity of the arch and high formability, in addition to being able to receive welding, without reducing its resilience, and being resistant to corrosion. They have elastic recovery superior to that of stainless steel, and can be flexed twice as much as stainless steel, without deforming permanently. Furthermore, they release forces that correspond to approximately half of the forces released by steel alloys for the same activation. Their high formability allows them to be conformed into various and complex loop configurations [14, 15, 16]. Nevertheless, Burnstone and Goldberg (1980) [17] do not reco mmend folds at acute angles for these alloys, affirming that making complicated loops to reduce the ri-

Table 2. Comparison between Class II and Class III for right and left side ($p \leq 0.05$)

Group	n	Mean (N)*	Standard Deviation (N)	F	p
Teardrop-8 mm-TMA	10	3.10^{A}	0.58	37.85	<0.01
Circle-8 mm-TMA	10	4.10^{AB}	0.65		
Teardrop-6 mm-TMA	10	4.88^{BC}	1.00		
Circle-6 mm-TMA	10	6.00^{C}	2.21		
Teardrop-8 mm-Stainless steel	10	6.41^{CD}	0.77		
Circle-8 mm-Stainless steel	10	6.93^{CD}	0.68		
Teardrop-6 mm-Stainless steel	10	7.85^{D}	1.87		
Circle-6 mm-Stainless steel	10	10.70^{E}	0.82		

NS – the difference is not statistically significant.

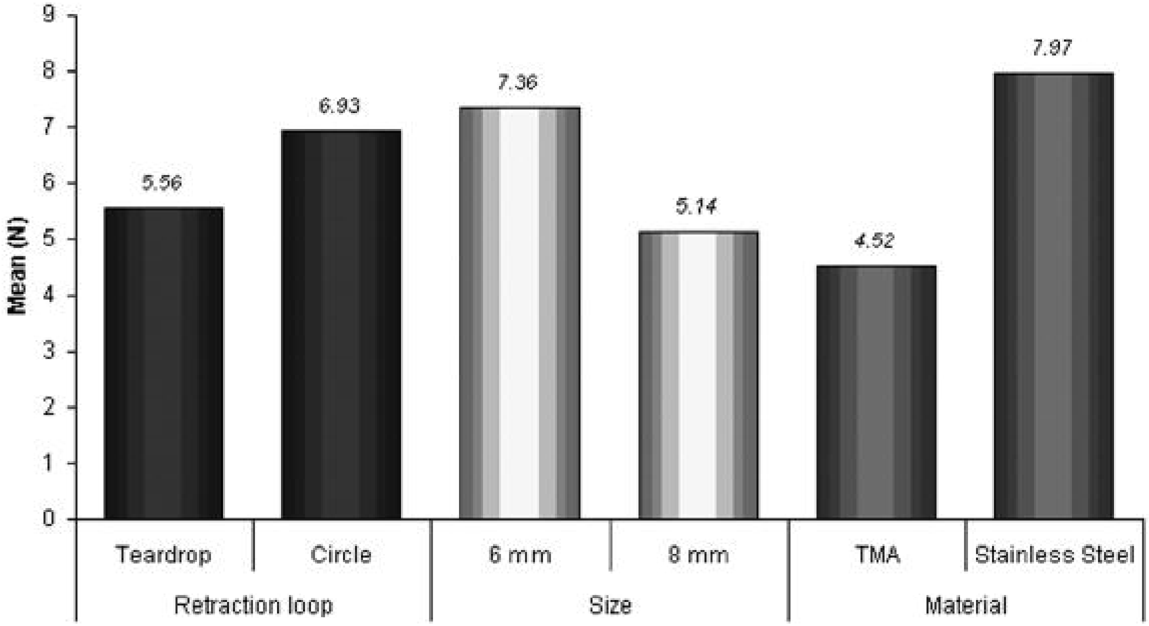

Fig. 4. Results of the comparison among the study variables

gidity of stainless steel alloys is not necessary for TMA wires. This could not be proved in the present study, as there was statistically significant difference among the groups of stainless steel alloy and those of TMA, suggesting that one could insert folds in this type of alloy and that it would even further improve the force generated by these types of loops for retraction.

The tensile test serves to predict the behavior of certain dental materials during their use [18]. In this study, this trial was used as the one that best simulates the forces generated during retraction in mass of the anterior teeth, in the case of closing spaces.

CONCLUSIONS

According to the study, it was concluded that the alloy of the wire and the height of the loop would be more important than the loop design, for the purpose of obtaining smaller biologic forces. The circle- and teardrop-shaped loops, made of TMA, presented the lowest values during the tensile test used. Nevertheless, the results of an in vitro study must be analyzed with caution, which leads to the necessity of more studies to clarify and define specific protocols for the use of retraction loops that bring greater advantages in clinical practice.

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