Tensile force measurement by using different lingual retainer wires, bonding materials types and thickness (A comparative in vitro study)

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ABSTRACT

Background: The bonded orthodontic retainer constructed from multistrand wire and composite is an efficient esthetic retainer, which can be maintained long-term. Clinical failures of bonded orthodontic retainers, most commonly at the wire/composite interface, have been reported. This in vitro investigation aimed to evaluate the tensile forces of selected multistrand wires and composite materials that are available for use in the construction of bonded fixed retainers.

Materials and Methods: The study sample includes 120 wires with three types of retainer wires (3 braided strands\ Orthotechnology, 8 braided strands\ G&H Orthodontics, 6 coaxial strands\ Orthoclassic wires), two types of adhesive (flowable\ Orthotechnology, non flowable\ G&H Orthodontics composites) and two thickness of the adhesive (1mm, 2mm). The samples were prepared for each composite in which a wire was embedded; then the composite was light cured for 40 seconds and the specimens were stored in artificial saliva at 37°C in the incubator for 24 hours. The ends of the wire were drawn up and tensile force was applied through Tinius-Olsen universal testing machine until the resin failed and the results were recorded in Newton (N).

Results: Statistical analysis showed that there was a highly significant difference ($P \leq 0.01$) among the mean values of tensile forces of the three types of retainer wires in each thickness of composite with exception of a non significant difference ($P > 0.05$) between (3 braided) and (8 braided) and a non significant difference ($P > 0.05$) between (3 braided) and (6 coaxial) in both thickness of composite, a highly significant difference ($P \leq 0.01$) between the two thickness of both composite types in each wire type and a highly significant difference ($P \leq 0.01$) between the two types of composite in each wire type of both thickness of composite.

Conclusion: The result of this study revealed that the 8 braided strands retainer wire shows the highest values of tensile force among the tested retainer wires, the non flowable composite demonstrates a higher tensile force than the flowable composite and increasing the thickness of composite overlying the wire increased the force required to detach the wire from the composite.

Key words: Retainer wires, flowable composite, tensile force. (J Bagh Coll Dentistry 2014; 26(2): 167-172).

INTRODUCTION

The phenomenon of relapse is well recognized and documented in the orthodontic literature [(1, 2)]. After active treatment is complete, long-term preservation of the corrected tooth positions is desirable, both for the clinician and for the patient. Unwanted post-treatment tooth movements have been attributed to a number of factors including periodontal fiber reorganization [(3)], growth changes after treatment [(4)], and type of treatment undertaken [(5)]. To counter such relapse, the employment of bonded retainers to the mandibular [(6)] or maxillary [(7)] incisors has become an established part of orthodontic practice. Bonded lingual retainers are fabricated in various designs which consist of a combination of different wires in various sizes and of different compositions [(8)].

Traditionally, bonded retainers have been attached to the teeth with composite. Various composites have been described for use in this technique including both restorative and orthodontic bonding materials. Thinning of the composite was previously advised to obtain the best handling characteristics, but there was still some difficulty [(9)]. Recently, the use of flowable composites, which were originally created for restorative dentistry by increasing the resin content of traditional microfilled composites, have been suggested for bonding lingual retainers [(10-12)].

This in vitro investigation aims to compare selected materials that are available for use in the construction of bonded orthodontic retainers to identify materials that may improve the clinical performance of these retainers. The wire tensile forces were tested in tensile model using three different types of lingual retainer wires with two types of bonding materials and two thickness of composite.

MATERIALS AND METHODS

Three types of retainer wires were used in this study:

1. Braided Retainer Wire (3 strands braided) (Orthotechnology)
2. Bond-A-Braid Lingual Retainer (8 strands braided) (Reliance Orthodontic Products)

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3. SRW™ Stranded Retention Wire (6 strands coaxial) (Orthoclassic).

Two types of bonding materials were used in this study:

1. Resilience® Low Viscosity Light-Cure Flowable Composite (Orthotechnology)
2. Light Cure Retainer (non flowable composite) (Reliance Bonding Products)

Cylindrical acrylic blocks (Figure 1) were prepared in metal molds, 25 mm in diameter and 10 mm height. Forty blocks were allocated to each of the three test groups, with a hole 3 mm in diameter and 4 mm deep in the upper surface of each block to represent the length of wire embedded in composite clinically in a bonded retainer. A 1 mm-wide groove in the upper surface across the diameter of the block to accommodate the wire. The groove with different depths of 1.0, 2.0 mm in each test group to represent the total depth of the wire and composite material on the tooth surface [13].

Figure 1: Acrylic blocks

Thin uniform coat of the bonding agent was applied by brush on surfaces of the hole of each block to be bonded. A 10-cm length of the tested wire was placed at the base of the groove and the empty insert in the center of the slot was filled with the testing material using the appropriate syringe, and excess is removed by carver. The composite was then light cured for 40 seconds. The ends of the wire were drawn up and twisted at a distance of 1 cm so that they could be secured using the attachment arm of the tensile load cell of the universal testing machine. With this arrangement, a force could be applied perpendicular to the long axis of embedded wire to cause wire pull out [13]. (Figure 2)

After completion bonding procedure, the specimens were allowed to bench set for 15 minutes to ensure complete polymerization of adhesive material. Then the specimens were immersed in artificial saliva and stored in the incubator at 37°C for 24 hours prior to tensile test.

Figure 2: The sample after bonding procedure

Tensile test was accomplished using a Tinius-Olsen Universal testing machine with speed of 10 mm/minute. The connected ends of the wire were secured and drawn up until separation of wire from composite occurs. The maximum force required to remove the wire from the composite was recorded [13] (Figure 3). The force required to remove the wire from the composite was recorded in Newton (N).

Figure 3: Tensile test

Statistical Analysis

Data were collected and analyzed using SPSS (statistical package of social science) software version 17 for windows XP. In this study the following statistics were used:

1. Descriptive Statistics: including; mean and standard deviation.
2. Inferential Statistics: including; One Way Analysis Of Variance (ANOVA), Least Significant Difference (LSD) and T- test.

RESULTS

Descriptive statistics and wire type's differences in each thickness in flowable composite

Descriptive statistics were performed for the three types of retainer wires (3 braided, 8 braided, and 6 coaxial) in each thickness of flowable composite. The (8 braided wire) showed higher mean values of tensile force than the 3 braided and 6 coaxial wires in both thickness of flowable composite and the (6 coaxial wire) showed the lowest value of tensile force in thickness 1 mm of flowable composite while in thickness 2 mm the (3 braided wire) showed the lowest value. (Table 1)

One way analysis of variance (ANOVA) showed a highly significant difference among the mean values of tensile forces of the three types of retainer wires in each thickness of flowable composite. (Table 1)

Then the least significant difference (LSD) test was performed to differentiate between the types of retainer wires in each thickness of flowable composite and showed a highly significant difference between wire types with exception of a non significant difference between (3 braided) and (8 braided) in 1 mm thickness and a non significant difference between (3 braided) and (6 coaxial) in 2 mm thickness of flowable composite.

Table 1: Descriptive data of tensile forces and ANOVA test between the three retainer wires types in flowable composite

Thickness of composite	Wire types	Descriptive statistics of tensile force (N)					Wire comparison ANOVA test	
		Mean	Max.	Min.	S.D.	S.E.	F-test	p-value
1mm	3 braided	17.9	23.5	13.5	3.13	0.99	15.07	0.000 **
	8 braided	20.05	23.5	18.5	1.69	0.53		
	6 Coaxial	13.9	18.5	11.5	2.59	0.82		
2mm	3 braided	51.3	61.5	41.5	7.16	2.26	22.24	0.000 **
	8 braided	70.2	78.5	60	8.28	2.62		
	6 Coaxial	53.25	58.5	41.5	5.09	1.61		

No. of samples for each group=10, (**) Highly significant difference

Descriptive statistics and wire type's differences in each thickness in non-flowable composite

The (8 braided wire) showed higher mean values of tensile force than the 3 braided and 6 coaxial wires in both thickness of non-flowable composite and the (6 coaxial wire) showed the lowest value of tensile force in thickness 1 mm of flowable composite while in thickness 2 mm the (3 braided wire) showed the lowest value. (Table 2)

One way analysis of variance (ANOVA) showed a highly significant difference among the mean values of tensile forces of the three types of retainer wires in each thickness of non-flowable composite. (Table 2)

Then the least significant difference (LSD) test was performed to differentiate between types of retainer wires in each thickness of non-flowable composite and showed a highly significant difference between wire types in each thickness of composite with exception of a non significant difference between (3 braided) and (8 braided) in 1 mm thickness of composite and between (3 braided) and (6 coaxial) in 2 mm thickness of composite.

Table 2: Descriptive data of tensile forces and ANOVA test between the three retainer wires types in non-flowable composite

Thickness of composite	Wire types	Descriptive statistics of tensile force (N)					Wire comparison ANOVA test	
		Mean	Max.	Min.	S.D.	S.E.	F-test	p-value
1mm	3 braided	35	43.5	23.5	5.61	1.77	31.63	0.000 **
	8 braided	36.1	43.5	31.5	4.16	1.32		
	6 Coaxial	21.9	26.5	16.5	3.23	1.02		
2mm	3 braided	93.75	103.5	85	5.53	1.75	47.05	0.000 **
	8 braided	126.65	133.5	115	6.39	2.02		
	6 Coaxial	94.45	108.5	73.5	12.40	3.92		

No. of samples for each group=10, (**) Highly significant difference

Descriptive statistics and thickness difference in each wire type in flowable composite

Descriptive statistics were performed for the two thickness of flowable composite (1 mm, 2 mm) in each retainer wire type. The thickness (2 mm) of flowable composite showed higher mean values of tensile force than the thickness (1 mm) in each type of retainer wires. (Table 3)

T-test showed a highly significant difference between thickness of flowable composite in each wire type. (Table 3)

Table 3: Descriptive data of tensile forces and t-test between two thickness of flowable composite in each retainer wire type

Wire types	Thickness of composite	Descriptive statistics of tensile force (N)					Thickness difference	
		Mean	Max.	Min.	S.D.	S.E.	t-test	p-value
3 braided	1mm	17.90	23.5	13.5	3.13	0.99	-13.52	0.000 **
	2mm	51.30	61.5	41.5	7.16	2.26		
8 braided	1mm	20.05	23.5	18.5	1.69	0.53	-18.76	0.000 **
	2mm	70.20	78.5	60	8.28	2.62		
6 Coaxial	1mm	13.90	18.5	11.5	2.59	0.82	-21.79	0.000 **
	2mm	53.25	58.5	41.5	5.09	1.61		

No. of samples for each group=10, (**) Highly significant difference

Descriptive statistics and thickness difference in each wire type in non flowable composite

Descriptive statistics were performed for the two thickness of non-flowable composite (1 mm, 2 mm) in each retainer wire type.

The thickness (2 mm) of non-flowable composite showed higher mean values of tensile force than the thickness (1 mm) in each type of retainer wires (Table 4). T-test showed a highly significant difference between thicknesses of non-flowable composite in each wire type. (Table 4)

Table 4: Descriptive data of tensile forces and t-test between two thickness of non-flowable composite in each retainer wire type

Wire types	Thickness of composite	Descriptive statistics of tensile force (N)					Thickness difference	
		Mean	Max.	Min.	S.D.	S.E.	t-test	p-value
3 braided	1mm	35	43.5	23.5	5.61	1.77	-23.58	0.000 **
	2mm	93.75	103.5	85	5.53	1.75		
8 braided	1mm	36.1	43.5	31.5	4.16	1.32	-37.57	0.000 **
	2mm	126.65	133.5	115	6.39	2.02		
6 Coaxial	1mm	21.9	26.5	16.5	3.23	1.02	-17.89	0.000 **
	2mm	94.45	108.5	73.5	12.40	3.92		

No. of samples for each group=10, (**) Highly significant difference

Descriptive statistics and material difference in each wire type of 1 mm thickness

Descriptive statistics were performed for the two types of bonding materials (flowable, non flowable composites) of thickness 1 mm in each retainer wire type.

The non-flowable composite showed higher mean values of tensile force than the flowable composite in each type of retainer wires (Table 5). T-test showed a highly significant difference between the two types of composite in each wire type of 1 mm thickness of composite (Table 5).

Table 5: Descriptive data of tensile forces and t-test between the 1 mm thickness of two types of composite in each retainer wire type

Wire types	Material	Descriptive statistics of tensile force(N)					Material difference	
		Mean	Max.	Min.	S.D.	S.E.	t-test	p-value
3 braided	Flowable	17.9	23.5	13.5	3.13	0.99	-8.42	0.000 **
	Non flowable	35	43.5	23.5	5.61	1.77		
8 braided	Flowable	20.05	23.5	18.5	1.69	0.53	-11.29	0.000 **
	Non flowable	36.1	43.5	31.5	4.16	1.32		
6 Coaxial	Flowable	13.9	18.5	11.5	2.59	0.82	-6.11	0.000 **
	Non flowable	21.9	26.5	16.5	3.23	1.02		

No. of samples for each group=10, (**) Highly significant difference

Descriptive statistics and material difference in each wire type of 2 mm thickness

Descriptive statistics were performed for the two types of bonding materials (flowable, non flowable composites) of thickness 2 mm in each retainer wire type.

The non-flowable composite showed higher mean values of tensile force than the flowable composite in each type of retainer wires. (Table 6)

T-test showed a highly significant difference between the two types of composite in each wire type of 2 mm thickness of composite. (Table 6)

Table 6: Descriptive data of tensile forces and t-test between the 2 mm thickness of two types of composite in each retainer wire type

Wire types	Material	Descriptive statistics of tensile force (N)					Material difference	
		Mean	Max.	Min.	S.D.	S.E.	t-test	p-value
3 braided	Flowable	51.3	61.5	41.5	7.16	2.26	-14.84	0.000 **
	Non flowable	93.75	103.5	85	5.53	1.75		
8 braided	Flowable	70.2	78.5	60	8.28	2.62	-17.07	0.000 **
	Non flowable	126.65	133.5	115	6.39	2.02		
6 Coaxial	Flowable	53.25	58.5	41.5	5.09	1.61	-9.72	0.000 **
	Non flowable	94.45	108.5	73.5	12.40	3.92		

No. of samples for each group=10, (**) Highly significant difference

DISCUSSION

Type and diameter of wire

The flattened eight-stranded wires (Reliance) with width of 0.64 mm (0.025 inch) gave the highest force values, followed by the three-stranded wires (Orthotechnology) with width of 0.71 mm (0.028 inch), this is because increasing the number of strands incorporated in each wire will increase the surface area of adhesion with the composite, while the six-coaxial wires (Orthoclassic) with width of 0.495mm (0.0195inch) giving the lowest value because the larger diameter wire, with greater surface area increase the retention of the wire with the composite when it is being pulling out of the composite.

Thickness of Composite

The force required to remove the wire from the composite increased, as expected, as the thickness of composite increased, the thickness of composite that actually overlies the wire is obtained by subtracting the wire depth, in this investigation 0.2 mm, from the depth of the groove. Therefore the thickness of composite overlying the wire in the 1.00 mm group is 0.8 mm, and in the 2.00 mm group represents specimens with 1.8 mm thickness of composite overlying the wire.

Type of composite

Statistical analysis reveals that there is highly significant difference between light cure retainer (non flowable composite) and light cure flowable composite as the light cure retainer (non flowable composite) give higher force values than the flowable composite. This is because as thinning of the composite advised to obtain the best handling characteristics but increasing the resin content of traditional microfilled composite as the flowable composites has a 20% to 25% lower filler content than conventional composites, in addition, a greater proportion of diluent monomers can be added to the composition, resulting in an increase in the ratio of resin to filler and a reduction in viscosity, this improved flowability allows these resins to be packaged in syringes with small-gauge dispensing needles, facilitating and simplifying placement. For direct resin-based materials (non flowable), the greater the filler content, the greater the mechanical properties, while flowable resins have significantly lower mechanical properties than conventional composites with their lower filler content, they are less rigid (lower elastic modulus) than conventional composites, this reduces the amount of force needed to remove the wire.

REFERENCES

1. Reidel RA. A review of the retention problem. Angle Orthod 1960; 30: 179-94. (IVSL)
2. Nanda RS, Nanda SK. Considerations of dentofacial growth in long-term retention and stability: is active retention needed? Am J Orthod Dentofacial Orthop 1992; 101: 297–302
3. Southard TE, Southard KA, Tolley EA. Periodontal force: a potential cause for relapse. Am J Orthod Dentofacial Orthop 1992; 101: 221–7.
4. Richardson ME. Late lower arch crowding: the role of differential horizontal growth. Br J Orthod 1994; 21: 379–385.
5. Sadowsky C, Schneider BJ, BeGole EA, Tahir E. Long-term stability after orthodontic treatment: non-extraction with prolonged retention. Am J Orthod Dentofacial Orthop1994; 106: 243-249.

6. Stormann I, Ehmer U. A prospective randomised study of different retainer types. J Orofacial Orthop 2002; 63: 42–50.
7. Naraghi S, Andren A, Kjellberg H, Mohlin BO. Relapse tendency after orthodontic correction of upper front teeth retained with a bonded retainer. Angle Orthod 2006; 76(4): 570-6. (IVSL)
8. Artun J, Spadafora AT, Shapiro PA, McNeill RW, Chapko MK. Hygiene status associated with different types of bonded orthodontic canine to canine retainers. J Clin Period 1987; 14 : 89 – 94
9. Zachrisson BU. Third generation mandibular bonded lingual retainer. J Clin Orthod. 1995; 29: 39 – 48.
10. Elaut J , Asscherickx K , Vande Vannet B , Wehrbein H. Flowable composites for bonding lingual retainers . J Clin Orthod 2002; 36: 597 – 8.
11. Geserick M, Ball J, Wichelhaus A. Bonding fiber-reinforced lingual retainers with color-reactivating flowable composite. J Clin Orthod 2004; 38: 560 – 2.
12. Geserick M, Wichelhaus A. A color-reactivated flowable composite for bonding lingual retainers. J Clin Orthod 2004; 38: 165 –6.
13. Bearn DR, McCabe JF, Gordon PH, Aird JC. Bonded orthodontic retainers: the wire-composite interface. Am J Orthod Dentofacial Orthop 1997; 111: 67–74