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Original Research Article

Comparison of bond strength of different lingual retainer wires: An *in vitro* study

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ABSTRACT

Background: Bonded retainers are extensively used after orthodontic treatment to maintain the achieved results. However, bond failure in the retainer system is a frequently observed problem, resulting in the loss of retainer function, leading to relapse.
Objective: The purpose of this in-vitro study was to compare the shear bond strength of different wire-composite combinations.
Materials and Methods: 144 extracted human premolars in pairs were divided into 6 groups of 12 samples each. The orthodontic retainer wires used were Flat woven wire (Leone), Dead soft retention wire (Ortho Classic USA) and two stranded twisted Leone ligature wire (0.018”). The composite that was used was Transbond XT adhesive (3M Unitek) and Enlight Light Cure Adhesive (Ormco). Retainer wires were bonded on the lingual surfaces of the teeth. 72 samples were subjected to debonding with a chisel head in a universal testing machine INSTRON. Comparisons of the means of shear bond strength values were made with one way ANOVA & Tukey’s Post Hoc test.
Results: Maximum shear bond strength was observed in group IA (Leone flat woven wire with Transbond XT). There was a statistically significant difference in the shear bond strength of different retainer wires.
Conclusion: Compared to other wire composite combinations, maximum shear bond strength was observed in Leone flat woven wire with Transbond XT composite. Therefore, it could be the wire-composite combination of choice for the bonded lingual retainer.

1. Introduction

Lingual bonded retainers have been popular since the late 1970s, particularly in the mandibular incisor area. However, bond failure in the retainer system is a frequently observed problem, resulting in the loss of retainer function, leading to relapse.

The phenomenon of relapse is well recognised and documented in the orthodontic literature. Post retention orthodontic treatment records reveal loss of stability and alignment, specifically in the mandibular anterior region.[1] Unwanted post-treatment tooth movements have been attributed to many factors, including periodontal fibre reorganisation, growth changes after treatment, and type of treatment undertaken. Therefore, permanent retention is highly recommended to ensure stability and maintain the long-term effects of the dentition achieved by the treatment. These consequences can be accomplished by a fixed lingual retainer inserted for an optimum time interval.[2]

Retention is one of the controversies of modern orthodontics, with uncertainty being the only certainty. Conventional lingual bonded retainers have been made of high dimension; round/rectangular wires fixed to the canines

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only. Later on, thin, flexible multistranded wires commonly 0.0195″ or 0.0215″ were bonded to each tooth from canine to canine.[3]

The success of these fixed retainers depends on various factors, mainly the diameter of the wire and its flexibility, the number of strands of wire and the bond strength with composite.[4] Flexible wires reduce the stress concentration within the bonding composite, thereby minimising bond failures. Authors have suggested many variations in the design of bonded fixed retainer. These include different wire types with differing diameters, other composites, and the use of mesh pads, intracoronal wire ligation with composite placed over the wires.[5] A good choice of wire for fixed retention must be flexible enough to allow physiologic tooth movement while exerting minimal forces on the teeth. It should also maintain the teeth in their intended position and be well retained on the teeth without the loss of dimensional stability.[6]

However, clinicians must be prudent in selecting the appropriate retainer with a wide array of choices. So, this study aims to compare the shear bond strength of different wire-composite combinations for lingual retention.

Figure 1: Leone flat woven wire

2. Objectives

1. To evaluate the shear bond strength of three different lingual retainers (Leone flat woven wire, Orthoclassic dead soft retention wire, Leone ligature wire)
2. To evaluate the shear bond strength of adhesive i.e, Transbond XT (3M Unitek) and Enlight Light Cure (Ormco).
3. To compare shear bond strength of different wire-composite combination.

Figure 2: Ortho classic dead soft retention wire

3. Source of Data

Study was carried out on 144 premolars without caries or fillings that had been extracted for therapeutic purposes in patients undergoing orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopaedics

4. Materials and Methods

1. 144 extracted premolar teeth
2. Flat woven wire (Leone S.p.a) (Figure 1)
3. Dead soft retention wire (Orthoclassic USA) (Figure 2)
4. Ligature wire (Leone S.p.a) (Figure 3)
5. Transbond XT adhesive (3M Unitek, Monrovia, CA, USA) (Figure 4)
6. Enlight Light Cure Adhesive (Ormco) (Figure 5)
7. Mini mold (Ortho Technology, USA)
8. Etchant and primer

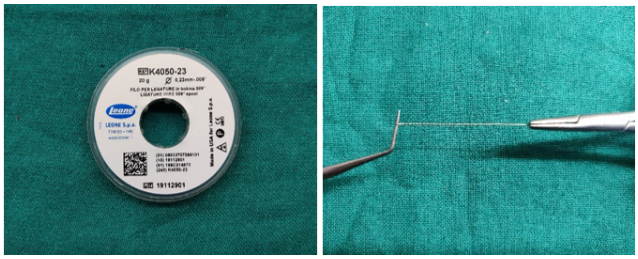


Figure 3: Leone ligature wire

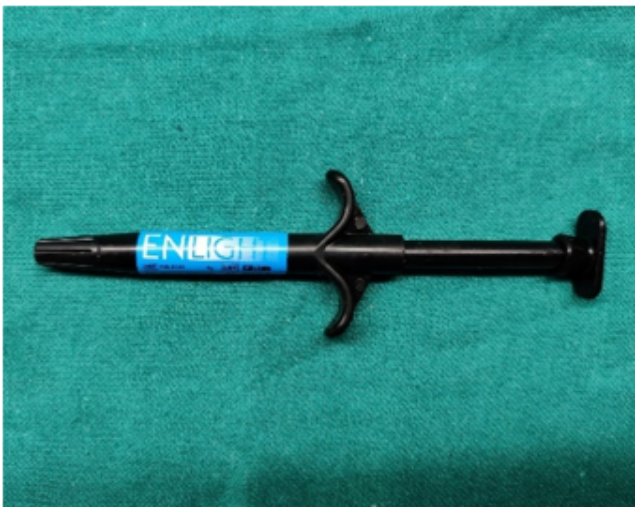


Figure 4: Enlight light cure adhesive

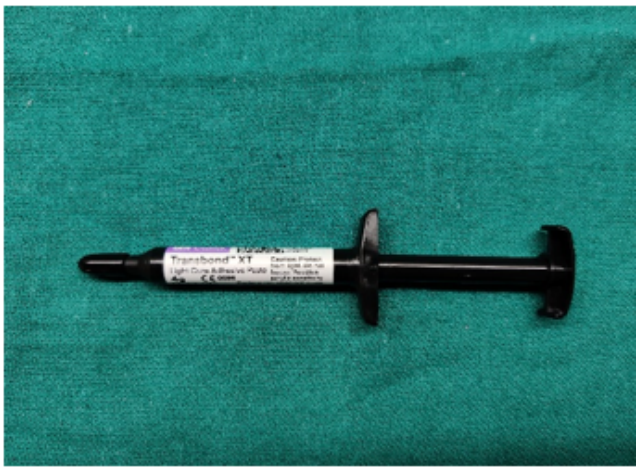


Figure 5: Transbond XT adhesive

5. Methodology

Shear bond strength was tested using an in vitro model designed such that a vertical force could be simulated at the interdental wire between two premolars. Each pair of premolars were mounted on an acrylic block. In preparation for the testing, two premolars were placed adjacent to each other to simulate a contact point in a specimen block. Custom made twisted stainless steel ligature wire retainers were fabricated by carefully twisting two 0.009" wires (Leone) using a Mathieu plier to form a passive yet sufficiently strong bundle. The extent to which the wires were twisted (the number of twists per millimetre of wire) was similar between all specimens. The wires were twisted clockwise, six rounds per 10 mm.

The enamel surface of each tooth is cleaned with pumice, washed with distilled water and dried with air. Lingual enamel surfaces, etched with 37% orthophosphoric acid gel for the 30s, followed by thorough washing and drying. A 15 mm length of lingual retainer wire gently curved for a passive fit to the lingual surfaces of the teeth is used for each specimen. Following primer application, the wire has been bonded with light cure adhesive. A commercially available dome-shaped mold wire bonder (Mini Mold-Ortho Technology) was used to standardise the amount of composite used for each bond. Seventy-two such models were prepared and divided into six groups (Group IA, IB, IC, IIA, IIB, IIC) of 12 each (Table 1,Figure 6).

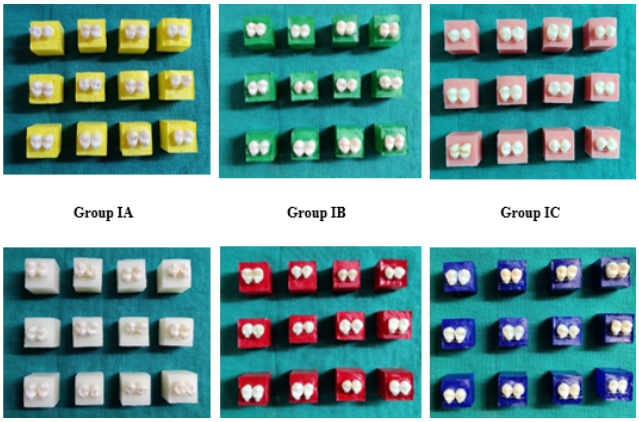


Figure 6: Sample groups

Shear bond strength was tested with a universal testing machine. Each specimen was placed and secured in the testing machine so that the chisel edge used to apply the force would not contact any part of the specimen. The vertical force was applied with the chisel edge to the midpoint of the interdental wire segment at a crosshead speed of 1 mm per minute. The bond strength was measured as the maximum force in Newton (N) to cause debonding /wire removal from the composite pad on at least one tooth in each specimen(Figures 7 and 8).

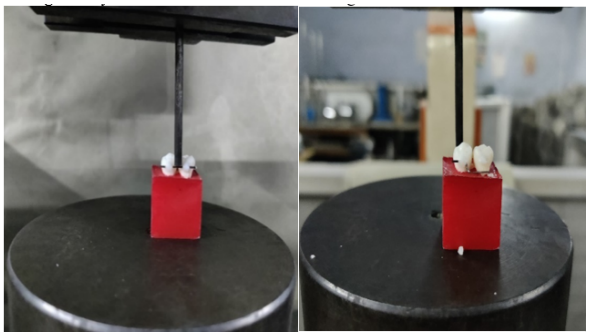


Figure 7: Acrylic block before and after debonding

Table 1: Sample segregation

Sl.	Subgroup	Details	Sample size
Group I Transbond XT	Group IA	Flat woven wire (Leone)	12
	Group IB	Dead soft retention wire (Ortho Classic USA)	12
	Group IC	Two stranded twisted ligature wire (0.018") (Leone)	12
Group II Ormco Enlight	Group IIA	Flat woven wire (Leone)	12
	Group IIB	Dead soft retention wire (Ortho Classic USA)	12
	Group IIC	Two stranded twisted ligature wire (0.018") (Leone)	12

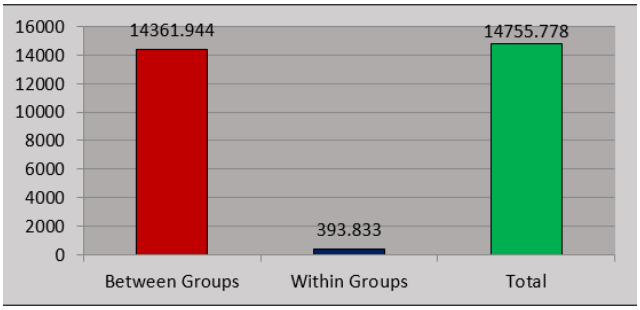
Table 2: Distribution of mean and S.D. Six subgroup's

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	P-value
				Lower Bound	Upper Bound			
Sub Group IA	99.16	2.918	0.842	97.312	101.027	95.00	104.00	
Sub Group IB	88.08	2.234	0.645	86.663	89.503	85.00	92.00	
Sub Group IC	61.92	1.975	0.570	60.661	63.171	59.00	65.00	0.001
Sub Group IIA	84.33	2.640	0.762	82.655	86.010	81.00	88.00	(Sig)
Sub Group IIB	74.50	2.110	0.609	73.159	75.841	71.00	77.00	
Sub Group IIC	59.66	2.640	0.762	57.989	61.344	55.00	64.00	

Table 3: Oneway ANOVA at a p-value less than 0.05 is significant.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14361.944	5	2872.38	481.365	0.001 (Sig)
Within Groups	393.833	66	5.96		
Total	14755.778	71			

Figure 8: SBS universal testing machine



Graph 1: One way anova

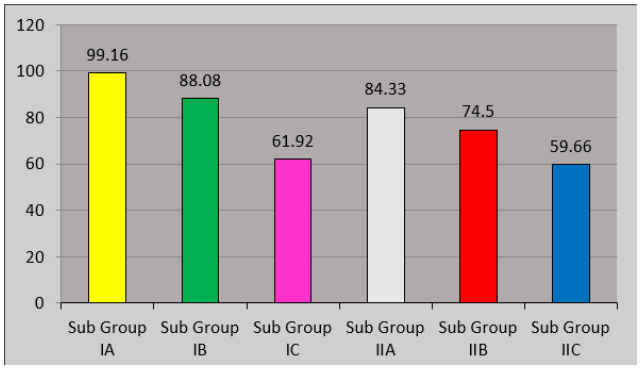
6. Results

6.1. Intergroup comparison between the subgroups

By applying one way ANOVA, there was a significant difference in means of SBS of six groups. Flat woven wire has higher shear bond strength than dead soft retention wire and ligature wire retainer.

Table 4: Post-Hoc Analysis

Group IA vs Group IB	11.083	0.997	0.001	Significant
Group IA vs Group IC	37.250	0.997	0.001	Significant
Group IA vs Group IIA	14.833	0.997	0.001	Significant
Group IA vs Group IIB	24.666	0.997	0.001	Significant
Group IA vs Group IIC	39.500	0.997	0.001	Significant
Group IB vs Group IC	26.166	0.997	0.001	Significant
Group IB vs Group IIA	3.750	0.997	0.001	Significant
Group IB vs Group IIB	13.583	0.997	0.001	Significant
Group IB vs Group IIC	28.416	0.997	0.001	Significant
Group IC vs Group IIA	-22.416	0.997	0.001	Significant
Group IC vs Group IIB	-12.583	0.997	0.001	Significant
Group IC vs Group IIC	2.250	0.997	0.001	Significant
Group IIA vs Group IIB	9.833	0.997	0.001	Significant
Group IIA vs Group IIC	24.667	0.997	0.001	Significant
Group IIB vs Group IIC	14.833	0.997	0.001	Significant

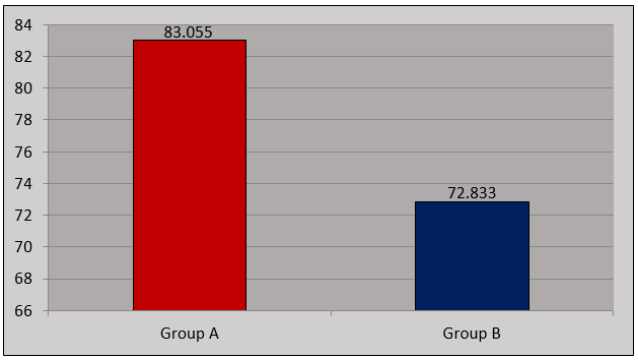


Graph 2: Distribution of mean SBS of six subgroups

6.2. *Post Hoc analysis*

Leone flat woven wire with Transbond XT composite has the maximum shear bond strength (91.16 N).

6.3. *Intergroup comparison between the groups*



Graph 3: Distribution of mean SBS of two different composites

When comparing composite material, Transbond XT (83.005N) has greater shear bond strength than Ormco Enlight (72.833N). Leone flat woven wire with Transbond XT composite has the maximum shear bond strength. Therefore, it could be the wire-composite combination of choice for a bonded lingual retainer.

7. Discussion

After active treatment is complete, long-term preservation of the corrected tooth positions is desirable, both for the clinician and the patient. Retention is essential and must continue until periodontal reorganisation has been fully completed. The purpose of this in-vitro study is to investigate the shear bond strength offered by the various combinations of lingual retainer wires and composite. The bonded wire retainer is a complex system on which forces are exerted from different directions. Long-term stability studies have shown that relapse after orthodontic treatment is unfortunately unavoidable. Thus, the maintenance of treatment effects via prolonged use of retainers is widely recommended.[7,8]

According to in vitro studies on bond strength, the detachment of a splinted wire is more frequently of cohesive type, taking place at the interface between the wire and the composite.[5,9] Therefore, proper resins should be used to increase the bond strength with the wires, avoiding the risk of failure with possible orthodontic relapse. Different retainer wire and composite combinations had significant differences in the shear bond strength.[10]

The present study was conducted to test and compare the shear bond strength offered by the various combinations of lingual retainer wires and composites. Leone flat woven wire was used because of its high plasticity. The wire permits the exact fit to the anatomy of the tongue while its woven geometry favours the union with the composite. There is no shear bond strength study related to the Flat-woven wire. Manufacturers claim that dead-

Table 5: Inter group comparison of SBS of two different Composites

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Group A	83.055	16.010	2.668	77.633	88.472	59.00	104.00
Group B	72.833	10.560	1.7601	69.263	76.406	55.00	88.00

Table 6: An independent t-test at a p-value less than 0.05 is significant.

T	df	Sig.	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
3.198	70	0.002	10.222	3.19659	3.846	16.597

soft wire is superior to multi-stranded stainless-steel wire for constructing Flexible spiral wire retainers. It is easily adaptable and minimises the inadvertent tooth movement associated with active force wires. The intra-arch splinting with this wire prevents torque control problems when round braided wires are used. They also state that the fattened wire increases patient comfort. Hence, this study used dead soft retention wire and two stranded twisted ligature wires. Ligature wire was twisted to form two stranded wire to increase the bond strength and adaptability to the tooth surface. Transbond XT and Ormco Enlight adhesive are commonly used in orthodontic practice. Hence, they were used in this study to compare their shear bond strength. The choice of etchant, primer, length of retainer wire and the steps in bonding was all the same in the six groups to minimise chances of errors.

The shear bond strength test was recorded using an Instron Universal Testing Machine. The debonding procedure was followed according to the method prescribed by Aldrees AM et al.[3] Bond strength investigations vary in their protocols, and this lack of standardisation makes scientific comparison difficult. While most of the published studies tested materials by one loading method applied directly at the bonding site of the orthodontic attachment, very few authors have examined the wire's interdental segment.[11]

In comparing the mean shear bond strength among six groups, ANOVA revealed a statistically significant difference ($P < .001$). Maximum shear bond strength was observed in group IA 98 (99.16 N), whereas the minimum was observed in group IIC (59.66N). This means that Flat woven wire has highest shear bond strength than Dead soft retention wire and Leone ligature wire. Twisted ligature wire showed the least shear bond strength. When comparing composite material, Transbond XT has greater shear bond strength than Ormco Enlight adhesive. According to Bryan and Sherriff[12], clinically acceptable mean shear bond strength for lingual bonded retainers was found to be 71 N. According to the results assessed in vitro and clinically, Transbond XT would be preferable to flowable composite when performing retainers bonding procedure.

According to Lie Sam Foek et al.[13], such in vitro studies can relate to in vivo conditions. However, more clinical studies may be needed to assess the effect of saliva, physiologic movement of teeth, functional forces of tongue, mastication, and the presence of plaque and calculus.

Therefore, from our study, it can be concluded that the most deciding factor in the shear bond strength is neither the wire nor the composite alone. It is the wire-composite combination that decides the ultimate shear bond strength. The combination of Leone Flat woven wire and Transbond XT produced the highest shear bond strength values, possibly due to the greater flowability of the resin around the strands of the wire, which increases the micromechanical retention and the flexibility of the Flat Woven wire, which adapted better to the tooth surface. All three retainer wires used in the study have a clinically acceptable mean shear bond strength. The cost and availability of the material also play a significant role in selecting the appropriate lingual retainer wire in a particular clinical situation.

8. Conclusion

This research attempted to assess the shear bond strength offered by the various combinations of lingual retainer wires and composites.

1. Maximum shear bond strength was observed in the wire-composite combination of Leone flat woven wire with Transbond XT composite.
2. A statistically significant difference in shear bond strength was observed between the six groups.
3. Transbond XT adhesive (Group I) has a greater shear bond strength than Ormco Enlight Light cure adhesive (Group II).
4. Leone flat woven wire with Transbond XT adhesive would be the wire-composite combination for a bonded lingual retainer.

Clinical studies are needed to validate the preliminary in vitro performance of retainers bonded to the lingual surface

of the teeth. Also, further in vivo studies can be conducted to validate the findings of the present in-vitro study.

9. Source of Funding

None.

10. Conflict of Interest

None.

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