EVALUATION OF THE SHEAR BOND STRENGTH OF THREE TYPES OF RETAINER WIRES BONDED WITH A COMPOSITE ADHESIVE - AN IN-VITRO STUDY

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ABSTRACT

BACKGROUND AND OBJECTIVES: Unwanted post treatment tooth movements are known as relapse. To counter such relapse, the employment of bonded retainers to the mandibular or maxillary incisors has become an established part of Orthodontic practice. Therefore, the purpose of this in- vitro study was to investigate the shear bond strength offered by the various combinations of lingual retainer wires and composite and the Yield strength (Y), Ultimate tensile strength (UTS) andw4 Modulus of Elasticity (E) retainer wires used.

MATERIALS AND METHOD: The materials used for the study included different orthodontic retainer wires and composite. The orthodontic retainer wires used was Ortho Flextech - Stainless Steel(Group 1), OrthoClassic Dead Soft Retention Wire(Group 2), and custom made twised wire (0.010" Stainless Steel Ligature)(Group 3). Composite that was used Transbond Lingual Retainer (3M Unitek,).The light cure unit used was from Elipar-3M ESPE. 90 human incisors with no visible enamel defects were used. Retainer wires were bonded on the lingual surfaces of the teeth. 45 samples were divided into 3 groups, which were subjected to debonding with a chisel head in UTM. Each retainer wire was tested for the flexural properties through tensile testing. Comparisons of the means of SBS values and flexural properties values were made with one way ANOVA & Post Hoc Tukey's.

RESULT: The SBS values of the three groups indicated statistically significant difference ($P < 0.05$) in which bond strength (MPa) is highest in the Group 2 followed by Group 1 and Group 3. In flexural properties custom made twised wire (0.010" Stainless Steel Ligature) was highest

CONCLUSION: The present study concluded that although there is significant difference in the mechanical properties of the different lingual retainer wires, they are still suitable for clinical use.

KEYWORDS: Lingual Retainer, Shear Bond Strength, Modulus Of Elasticity, Ultimate Tensile Strength, Yield strength

INTRODUCTION

Retention is one of the controversies of modern orthodontics, with uncertainty being the only certainty. Angle stated that "the problem involved in retention is so great as to test the utmost skill of the most competent orthodontist, often being greater than the difficulties being encountered in the treatment of the case up to this point."

A certain amount of relapse is almost inevitable following orthodontic therapy, particularly in the lower anterior segment. Therefore, the need for secure retention after orthodontic treatment is unquestioned, and the bonded wire retainer is the appliance of choice for the modern orthodontist.[1]

In the early literature, retention is discussed very briefly; however most of the authors of this period advocate the support, or "fixation", a term frequently used, of newly moved teeth until they have become firm in their new positions. Factors operating before, during, or after this fixation period are given little consideration.[2]

Oppenheim believed that during retention the teeth should be permitted as much freedom as possible, thereby allowing for a quicker readjustment of the bone. He recommended that cases should be overcorrected, followed by a long period of retention.[3]

In post-active orthodontic treatment, two types of retainers are given: a removable type and a fixed type. The removable retainers have been fast losing ground due to the factor of patient non-compliance. Therefore, in recent times, the bonded wire retainer has emerged as an appliance of choice for the modern orthodontist.

Bonded retainers are extensively used after orthodontic treatment with fixed appliances to maintain the achieved result by preventing secondary crowding of incisors after tooth alignment. Early bonded fixed retainers were made with plain round or rectangular orthodontic wires.[4]

The development of dental resin based composite restorative materials started in the late 1950s and early 1960s by Bowen. Nowadays, composites are presently the most popular tooth colored materials.[5]

On the other hand, when the correct retention is difficult or impossible to achieve with traditional removable appliances, flexible spiral wire retainers are considered are appropriate and they are independent of patient cooperation. They also allow slight movement of all bonded teeth and segments; they are highly efficient and almost invisible[1].

Therefore the purpose of this in- vitro study is to investigate the shear bond strength offered by the various combinations of lingual retainer wires and composites and to test the flexural properties of the lingual retainer wires being used.

AIMS AND OBJECTIVES

The aim of the present study is to evaluate and compare the SBS of three lingual retainer wire namely Ortho Flextech - Stainless Steel(0.974mmx 0.402mm) [Reliance Orthodontics], OrthoClassic Dead Soft Retention Wire[Libral Traders] and custom made twised wire (0.010" Stainless Steel Ligature{ HP Company})

The objectives of this study are to determine:

The Flexural properties of the lingual retainer wires being used

SOURCE OF DATA

In this study, 90 human mandibular anterior teeth, extracted from patients undergoing routine extractions after taking their consent, at the Department of Oral and Maxillofacial Surgery, M. R. Ambedkar Dental College and Hospital, Bangalore were obtained.

Exclusion criteria:

Decayed teeth ,
Fluorosed teeth,
Attrited teeth,
Restored teeth.
Hypoplastic teeth and Fractured teeth

MATERIALS and METHODS

1. 90 human mandibular anterior teeth
2. Ortho Flextech - Stainless Steel(0.974mmx 0.402mm) [Reliance Orthodontics]
3. OrthoClassic Dead Soft Retention Wire[Libral Traders]
4. Custom made twised wire (0.010" Stainless Steel Ligature{ HP Company})
5. Transbond LR (3M Unitek, Monrovia, California, USA)
6. Applicator
7. PVC pipe (0.50 diameter)
8. Primers [Transbond LR (3M Unitek, Monrovia, California, USA)]
9. 37% Orthophosphoric acid (Scotchbond™, 3M)
10. Acrylic (Pink, DPI-RR Cold Cure, Dentsply)
11. Ultrasonic Dental scaler (EMS)
12. LED curing light (3M ESPE Elipar)
13. Mathieu pliers
14. Universal testing machine. (Fine testing machine)

METHODOLOGY

Each pair of incisors were mounted on an acrylic block inside a PVC pipe (0.50" Diameter). In preparation for the testing, two incisors were placed adjacent to each other to simulate a contact point in a specimen block. The specimen block dimensions allowed it to be held in the clamp of a Universal Testing Machine.

The enamel surface of each tooth was cleaned with non- fluoridated pumice, washed with distilled water and dried with air. The enamel surfaces were etched with 37 percent orthophosphoric acid gel (Scotchbond™, 3M) for 30 seconds, seconds and the teeth rinsed with water and dried with oil free air for 10 seconds, Following application of the primer (Transbond XT system; 3M Unitek) and light cured for 10 seconds with a LED curing light (3M ESPE, Elipar S10), a passive 15 mm wire length was bonded with light cure adhesive (Transbond LR adhesive; 3M Unitek) between the pairs of teeth in each specimen block. A commercially available dome-shaped mold wire bonder (Mini-Mold™; Ortho-Care Ltd, Bradford, West Yorkshire, UK) was used to standardize the amount of composite used for each bond. The mould had a groove that allowed the operator to locate the composite so that the wire was in the middle of the composite bond.

The 45 specimen blocks (Each specimen had 2 pair of incisor) were divided into three groups for testing, 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. For each specimen, the maximum force, in Newton (N), required to cause failure was recorded i.e. wire removal from the composite pad on at least one of the incisor pair in a specimen converted to MPa.

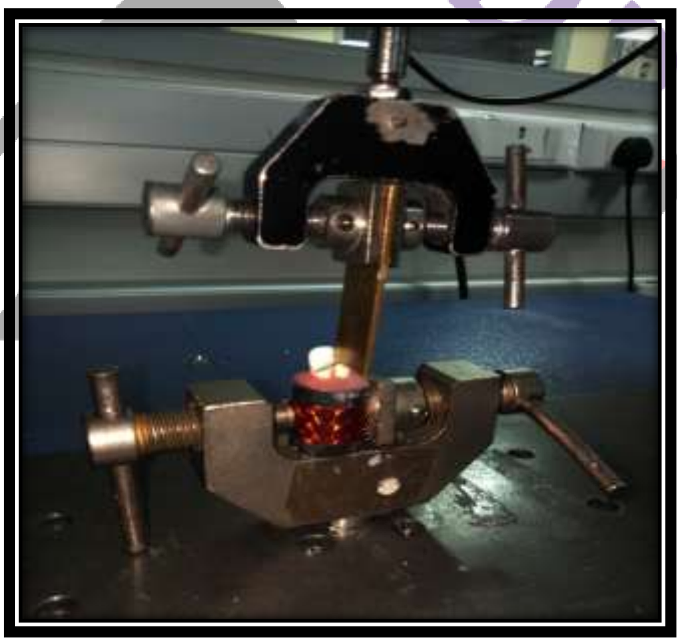
ULTIMATE TENSILE STRENGTH, YIELD STRENGTH AND MODULUS OF ELASTICITY

A standard tensile test using each of the lingual retainer wire from groups 1-3were performed in a Universal Testing Machine. A full-scale load of 1000 N was set in the machine with a crosshead speed of one mm/minute. The span of the wire between crossheads was standardized as 6 inches. The load taken to break the wire divided by the cross-sectional area of the wire gave the value for Ultimate Tensile Strength. The deflection data obtained from the tensile were plotted as stress-strain curves from which the Modulus of Elasticity as well as 0.2% offset Yield Strength were calculated.

Ortho Flextech - Stainless Steel(0.974mmx 0.402mm) [Reliance Orthodontics]

OrthoClassic Dead Soft Retention Wire[Libral Traders]

Custom made twised wire (0.010” Stainless Steel Ligature{ HP Company})



A Test Specimen In The Clamp Of The Universal Testing Machine, Showing An Incisor Pair With A 15 Mm Length Of Wire Bonded To The Lingual Surfaces Of The Teeth.

RESULTS

The lingual retainer wires and composite used in the study are:

GROUP	SPECIMENS FOR TESTING SHEAR BOND STRENGTH
GROUP I : ORTHO FLEXTECH - STAINLESS STEEL	15
GROUP II : ORTHOCLASSIC DEAD SOFT RETENTION WIRE	15
GROUP III : CUSTOM MADE TWISED WIRE (0.010" STAINLESS STEEL LIGATURE{ HP COMPANY})	15

TABLE – 1
COMPARISON OF MEAN SHEAR BOND STRENGTH (IN MPa) BETWEEN 3 GROUPS USING ANOVA TEST

Groups	Number	Mean	SD	MIN	MAX	P VALUE
Group 1	15	63.468	15.63	34.8	84.8	
Group 2	15	175.294	75.23	88	353	0.0001*
Group 3	15	107.593	54.91	33.9	222	

** - Statistically Significant*
Note:
Group 1 - Ortho Flextech - Stainless Steel, Group 2 -, Orthoclassic Dead Soft Retention Wire, Group 3 - 0.010" Stainless Steel Ligature Wire

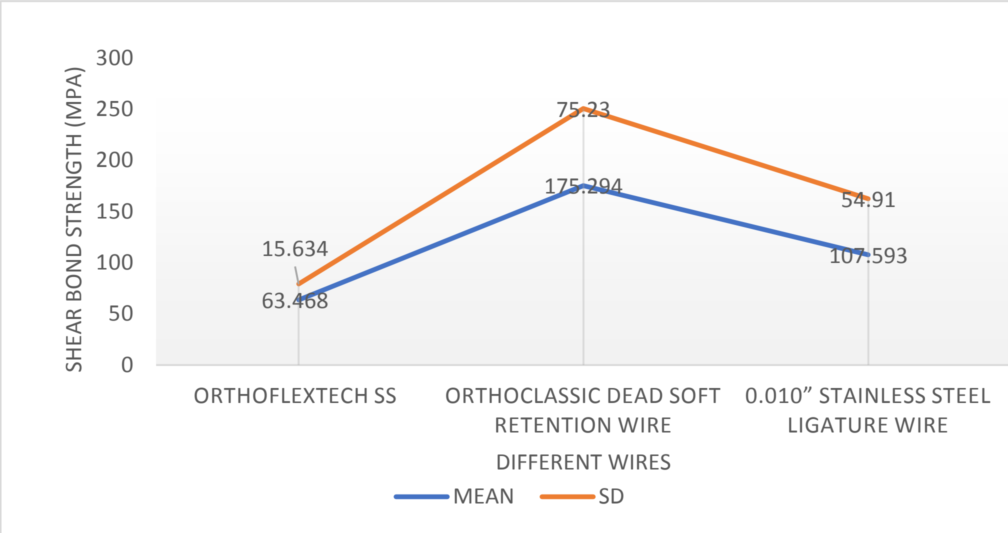
TABLE 2
MULTIPLE COMPARISON OF MEAN DIFFERENCES IN SHEAR BOND STRENGTH (IN MPa) IN GROUPS USING TUKEY HSD

Group(I)	Group(J)	Mean difference (I-J))	SD	95% of confidence interval		P VALUE
				Lower	upper	
Group 1	Group 2	111.83	12.43	63.4594	160.2006	0.0001*
	Group 3	43.83	3.66	-4.5406	92.2006	0.0826
Group 2	Group 3	-68.00	10.29	-116.3706	-19.6294	0.0040*

Following ANOVA, Pair wise multiple comparison between the groups was done using Tukey's Post Hoc Test by determining HSD (Honest Significant Difference).

Group 1 shows statistically significant difference in bond strength with Group 3 but no significance with Group 2. Group 2 and 3 shows statistical significance.

GRAPH 1- : ASSOCIATION OF SHEAR BOND STRENGTH BETWEEN THREE LINGUAL RETAINER BOND WIRES



ULTIMATE TENSILE STRENGTH, YIELD STRENGTH AND MODULUS OF ELASTICITY

TABLE 3

COMPARISON OF MEAN (IN MPa) BETWEEN 3 GROUPS USING ANOVA TEST

Groups	Number	Mean	SD	MIN	MAX	P VALUE
Group 1	3	148.05	2.65	145.87	151	
Group 2	3	202.31	47.72	155.31	250.72	**0.0002***
Group 3	3	410.05	31.09	378.54	440.71	

* - *Statistically Significant*

TABLE 4

COMPARISON OF MEAN (IN MPa) BETWEEN 3 GROUPS USING ANOVA TEST

Groups	Number	Mean	SD	MIN	MAX	P VALUE
Group 1	3	108.6	12.85	95.65	121.35	
Group 2	3	170.67	29.38	135.13	200.90	**0.0001***
Group 3	3	272.72	24.94	251.14	300.03	

* - *Statistically Significant*

TABLE 5

COMPARISON OF MEAN (IN GPa) BETWEEN 3 GROUPS USING ANOVA TEST

Groups	Number	Mean	SD	MIN	MAX	P VALUE
Group 1	3	0.54	59.38	0.48	0.6	
Group 2	3	3.09	100.095	2.99	3.19	**0.0001***
Group 3	3	8.24	582.597	7.75	8.89	

- **Statistically Significant*

DISCUSSION

Riedel recognized that after orthodontic treatment, the teeth tend to return to their original positions because the periodontal tissues have not had sufficient time to reorganize themselves. During this reorganization period, the teeth must be maintained in the position achieved orthodontically, by means of removable or fixed retention systems[6]. It takes 232 days for rearrangement of principle fibers.[7] Retention is consequently important and must continue until periodontal reorganization has been fully achieved.

Clinically, the reliable bonding of lingual wire retainers is important. The bonded wire retainer is a very complex system on which forces are exerted from different directions. For that reason, shear bond strength, cantilever loads, torque, and tensile strength tests can be performed to evaluate the bond strength of the wire to the enamel.

Limiting the tooth type to human incisors only, the most frequent site for bonded retainers, variations exists in the lingual morphology, age of enamel, and tooth size[8], which would have had effects on the moment of forces created at the bonded interfaces.

Artun and Zachrisson first described the clinical technique for the use of a multistrand wire canine-to-canine bonded fixed retainer. In this retainer the wire was bonded to the canine teeth only. In 1983, Zachrisson reported the use of multistrand wire in a bonded fixed retainer in which the wire was bonded to all the teeth in the labial segment.[9]

In this study it was found that the shear bond strengths of all the groups were:

Group 1=63.46MPa, Group 2 = 175.294MPa, Group 3= 107.593MPa. This clearly indicates that Orthoclassic Dead Soft Retention Wire Ortho Flex-Tech - Stainless Steel wire i.e. Group 2 is having the highest shear bond strength and Ortho Flex-Tech - Stainless Steel wire has the least shear bond strength with 0.010" Stainless Steel Ligature Wire being the intermediate.

One way ANOVA (Table 1) test revealed that the different groups exhibited different bond strengths which were statistically significant. On comparing the shear bond strength of the different groups of retainer wire with each other using post hoc Tukey's test (Table 2) statistically significant ($P<0.05$) difference in the shear bond strength was found among the groups.

Reynolds, [10] who assumed that bonded orthodontic appliances should withstand 5–8 MPa. In his opinion, these forces are composed of chewing forces and other internal forces. There would appear to be little information in the literature on the minimum clinically accepted bond strength in relation to bonded retainer wire.[11]

There is also lack of studies in the literature that have examined a force applied to an interdental segment of bonded retainer wire. Hence this study was undertaken to examine the force required to debond a segment of a bonded retainer wire when a vertical force was applied to an interdental segment of wire. Complex forces arise when a vertical force is applied to a wire bonded at the ends and tension, shear, and torsion forces may occur simultaneously.[11]

On introduction of the horizontal tension force vector to the wire, there was an increase in early failure at the composite–wire interface (cohesive failure). In the present study, the application of a vertical force to the midpoint of the interdental wire would have resulted in complex multi-vectorial forces across the two bond sites in each specimen leading to some horizontal tensional forces. The mean forces between the groups were Group I (22.9 N), Group II (36.87N) and (23.01N).

Waters[12] noticed that the normal range of oral forces is 3–18 N. In our study the SBS of all tested retainer wires have exceeded these values and should therefore show clinically sufficient shear bond strengths.

The type of composite and bonding agent are important factors in the failure rate of lingual retainers. In this study, the composite was Transbond LR and bonding agent was Transbond XT primer. It must be remembered that the data analysis from this study is relevant to the *in vitro* application of the specific adhesive, and does not account for the many *in vivo* dependent variables e.g. temperature, saliva, cyclic loading from mastication, or microbial effects.[13]

The present study was aimed at characterizing three commercially available retainer wires in orthodontics based on their mechanical properties. A comparison between the load deflection properties was also performed to provide an insight into their use in orthodontics.

A stiffer material will have a higher elastic modulus

$$E = \frac{stress}{strain}$$

Where stress is the force causing the deformation divided by the area to which the force is applied and strain is the ratio of the change in some length parameter caused by the deformation to the original value of the length parameter[14].

This makes Group 3 wire stiffer (E – 8,24 GPa), Group 2 (E- 3.09 GPa) and Group 3 (E-0.54 GPa).

A yield strength of a material is defined as the stress at which a material begins to deform plastically or exhibits a specific amount of plastic strain. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed.[15]

Upon tensile evaluation, Group 3 showed highest yield strength compared to the other groups.

The strength (MPa) is highest in Group 3 (272.72) followed by Group 2 (170.67) and Group I (108.6).

Ultimate tensile strength (UTS), often shortened to tensile strength (TS) or ultimate strength, is the maximum stress that a material can withstand while being stretched or pulled before failing or breaking. Upon tensile evaluation, Group 3 showed highest ultimate tensile strength compared to the other groups. The strength (MPa) is highest in Group 3 (410..05) followed by Group 2 (202.31) and Group 1 (148.05).. On comparing the mechanical properties of the different groups of retainer wires were statistically significant.

However, 0.010" custom made stainless steel ligature wire has higher Modulus of elasticity, UTS, and YS but have intermediate shear bond strength, can be considered for Lingual Retainer wire but care must be taken as it is very stiff wire. In the present study, Orthoclassic Dead Soft Retention Wire has the highest shear bond strength and intermediate UTS, YS and Modulus of elasticity, it can be considered as an option for lingual retainer wire

Ortho Flextech-Stainless steel has the lowest shear bond strength ,UTS , YS and Modulus of elasticity, one must be careful while using it. Since there is no study done on Orthoclassic Dead Soft Retention Wire

and Ortho Flextech-Stainless steel, further studies must be conducted to validate.
As been discussed before, care should be taken while extrapolating the in-vitro properties of a material in the in-vivo environment as there could be some differences in the mechanical characteristics. The cost of the material also plays a significant role in selecting the appropriate lingual retainer wire in a particular clinical situation. Further in vivo studies can be conducted to validate the findings of the present in-vitro study.

CONCLUSION

Unwanted post treatment tooth movements are known as relapse. To counter such relapse, the fixing of bonded retainers to the mandibular or maxillary incisors has become an established part of Orthodontic practice.

0.010" custom made stainless steel ligature wire has higher Modulus of elasticity, UTS, and YS but have intermediate shear bond strength, Orthoclassic Dead Soft Retention Wire has the highest shear bond strength and intermediate UTS, YS and Modulus of elasticity, it can be considered as an option for lingual retainer wire Ortho Flextech-Stainless steel has the lowest shear bond strength ,UTS , YS and Modulus of elasticity; although there is significant difference in the mechanical properties of the different lingual retainer wires, they are still suitable for clinical use.

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