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Original Article

Dentistry Section

Comparative Evaluation of Microleakage of Lingual Retainer Wires Bonded with Three Different Lingual Retainer Composites: An In Vitro Study

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ABSTRACT

Objective: To evaluate microleakage when two types of retainer wires were bonded with two light cured and a self cured lingual retainer composites.

Materials and Methods: Total 120 freshly extracted human mandibular incisor teeth were collected and separated into six subgroups of 20 teeth each. Two different wires, a 0.036 inch hard round stainless steel (HRSS) wire sandblasted at the ends and 0.0175 inch multistranded wire bonded onto the lingual surfaces of the incisors with three different types of composite resins of 3M company; Concise Orthodontic (self-cure), Transbond XT (light-cure) and Transbond LR (light-cure). Specimens were further sealed with a nail varnish, stained with 0.5% basic fuchsine for 24 hours, sectioned and examined under a stereomicroscope, and scored for microleakage for the enamel-composite and wire-composite interfaces. Statistical analysis was performed by Kruskal-Wallis and Mann-Whitney U-tests.

Results: For HRSS wire, at the enamel-composite interface, the microleakage was least with Transbond LR followed by Concise Orthodontic and greatest for Transbond XT ($p<0.05$). At the wire composite interface too, the microleakage was in order of Transbond LR<Concise Orthodontic<Transbond XT. For the multistranded wire, at the enamel-composite interface, the microleakage was least with Transbond LR followed by Concise Orthodontic and Transbond XT ($p<0.05$). At the wire composite interface too, it was seen that microleakage was the least with Transbond LR followed by Concise Orthodontic and Transbond XT.

Conclusion: Transbond LR in combination with 0.0175 inch multistranded wire showed least microleakage amongst the groups studied.

Keywords: Lingual retainer, Microleakage, Orthodontic composites

INTRODUCTION

Retention is one of the controversies of modern orthodontics, with uncertainty being the only certainty [1]. The cases that will relapse cannot be predicted and that indefinite retention is necessary if the finished result of active orthodontic treatment is to be maintained [2]. The clinician, in consultation with each patient, must determine the appropriate retention regimen for each case [3]. Initially the appliances for retention of post treatment tooth position proposed were based on banded fixed appliances [4]. Removable retainers were subsequently advocated for use [5]. Bonded lingual retainers are fabricated in various designs which consist of a combination of different wires in various sizes and of different compositions and physical structures [6]. The multi-stranded wire has proved to be superior as compared to plain, round wires due to its irregular surface which offers increased mechanical retention for the composite without the need of the placement of retentive loops [7]. Different composites have been described for use in this technique including both restorative materials and orthodontic bonding materials [8].Concise, a conventional restorative composite based on Bis-GMA is a commonly used self cure composite resin for bonded retainers [9]. Concise orthodontic is manufactured with decreased viscosity to aid handling, however it was unclear in some studies in the literature whether this or restorative material was used [9]. The fabrication of lingual retainers require meticulous and time consuming work, therefore, many clinicians prefer to use visible light-cured composites over chemically cured ones [10]. It has been shown that Concise orthodontic and Transbond XT (a conventional light cured orthodontic composite) compare favorably because of their abrasion resistance and strength [11]. Transbond LR is a highly filled light cured composite which is specially manufactured for lingual retainers [12]. Larger round stainless steel wires are seen to fail more often than thinner stranded wires [13]. The most common failure type is detachment at the composite-wire interface because of insufficient adhesive over the wire or unfavorable occlusal contacts which results in abrasion of the composite [14]. Microleakage beneath bonded orthodontic attachments may be a reason for failures too. In the literature, different band cements [15], light sources [16] and brackets [17] have been evaluated for microleakage but these studies primarily focused on enamel demineralization. Microleakage beneath composites is particularly important in orthodontics especially for lingual retainer adhesives, as they are exposed to the oral cavity and are intended to serve in mouth for a long period of time. Gap formation contributes to microleakage, permitting the passage of bacteria and oral fluids into oral cavity [18]. Though Concise orthodontic, Transbond XT and Transbond LR are almost comparable in hardness, they have not been collectively evaluated for microleakage at the enamel-composite and wire-composite interface. Hence this study was planned to evaluate microleakage with respect to the third generation sandblasted 0.036 inch Hard Round Stainless Steel wire and a second generation flexible spiral 0.0175 inch co-axial wire.

MATERIALS AND METHODS

Total 120 mandibular incisors extracted for periodontal involvement or any therapeutic purposes were collected from Department of Oral and Maxillofacial Surgery. Immediately before bonding, the teeth were cleaned using an ultrasonic-scaler to remove tissue tags, plaque. The teeth were polished using non-fluoridated, oil-free, pumice paste rinsed with water and dried with an oil and moisture free air spray for 30 seconds. Two different wires, a 0.036 inch hard round stainless steel wire (HRSS) sandblasted at the ends and 0.0175 inch multistranded wire (M) bonded onto the lingual surfaces of the incisors with three different types of composite resins; (1) a self curing composite, Concise Orthodontic, (2) a light cured composite used for orthodontic bonding, Transbond XT 3) a light cured composite specifically manufactured for lingual retainer bonding, Transbond LR.

All 120 teeth were divided into 3 main groups and further 2 subgroups in each group (making total 6 subgroups with 20 teeth each) [Table/Fig-1]. The bonding method for each material has been described in [Table/Fig-2]. After bonding, the apices of the teeth were sealed with sticky wax, rinsed under tap water and air dried. All the teeth were then kept in 0.5% solution of basic fuchsine for 24 hours at room temperature. The samples were brushed off to remove superficial dye and the composite bulk was sectioned parallel to the lingual retainer wire at low speed with a water cooled diamond disc [Table/Fig-3]. The specimens were then evaluated for dye penetration along the enamel-composite interface. The wires were then gently removed from the composite bulk and the dye penetration was evaluated between the adhesive-wire interface on mesial and distal side. Direct measurement of the length of the penetrated dye was made using a digital caliper with an accuracy of 0.01 mm [Table/Fig-4a, b]. The measurements were repeated by another observer and subjected to statistical evaluation (Kappa test) to evaluate for inter-examiner method error.

The Kappa scores for assessment of microleakage for Concise Orthodontic, Transbond XT, and Transbond LR were calculated. The inter examiner kappa scores for assessment of microleakage were high, with all values greater than 0.8 [Table/Fig-5]. It indicates fair amount of agreement between observations taken by two observers, thus validating the procedure. Descriptive statistics including mean, standard deviation, minimum and maximum values of microleakage are presented in [Table/Fig-6]. Microleakage between the two wires 0.036" HRSS wire and 0.0175" coaxial wire was assessed at two sites (mesial and distal) and at two interfaces (enamel-composite and wire-composite).

RESULTS

Microleakage utilizing the three composites with respect to 0.036" HRSS wire:-

For HRSS wire, at the enamel-composite interface, it was seen that microleakage was least with Transbond LR followed by Concise Orthodontic and greatest for Transbond XT. These values for microleakage for three composites studied were statistically significant ($p<0.05$) [Table/Fig-7] and when a pair wise evaluation was carried out, significant differences ($p<0.05$) [Table/Fig-8] were noted between the groups for both mesial and distal ends of the wire at wire composite interface. At the enamel composite interface too, it was seen that microleakage was the least when Transbond LR was used followed by Concise Orthodontic and Transbond XT.

Microleakage utilizing the three composites with respect to 0.0175" multistranded wire:-

For the 0.0175 multistranded wire, at the enamel-composite interface, it was seen that microleakage was least with Transbond LR followed by Concise Orthodontic and greatest for Transbond XT ($p<0.05$) [Table/Fig-7]. At the wire composite interface too, it was seen that microleakage was the least with Transbond LR followed by Concise Orthodontic and Transbond XT [Table/Fig-7]. When the microleakage values at the enamel composite interface was compared with that at the wire composite interface (for both the wires), it was noted that the microleakage at the two interfaces were more or less equal.

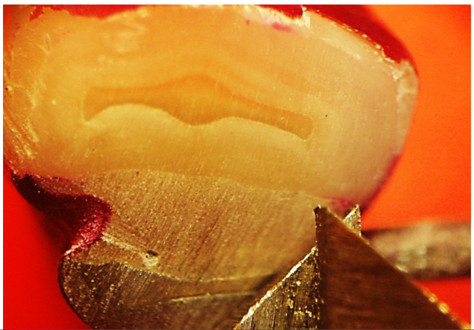
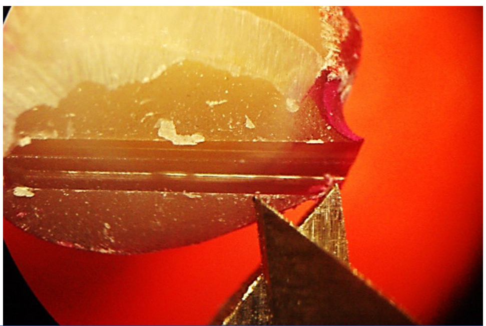
Comparison of microleakage utilizing the three composite resins with respect to both the 0.036" HRSS wire and 0.0175" multistranded wire:-

Composite	Concise (Group I)		Transbond XT (Group II)		Transbond LR (Group III)	
Wire	0.036" SS wire sandblasted at ends(a)	0.0175" Coaxial wire(b)	0.036" SS wire sandblasted at ends(a)	0.0175" Coaxial wire(b)	0.036" SS wire sandblasted at ends(a)	0.0175" Coaxial wire(b)
Groups	I(a)	I(b)	II(a)	II (b)	III(a)	III(b)
Teeth	20	20	20	20	20	20

[Table/Fig-1]: The details of subgroups

Group	Material	37% Ortho-phosphoric Acid etching Time	Priming		Composite Application	
			Primer	Light curing time	Composite	Light curing time
I	Concise	15 Sec	Concise Resin A and Resin B (mixing for 10 Sec)	-------	Concise Orthodontic paste A and paste B (mixing for 10 Sec)	--------
II	Transbond XT	30 Sec	Transbond XT primer	10 Sec	Transbond XT orthodontic composite	20 Sec
III	Transbond LR	30 Sec	Transbond XT primer	10 Sec	Transbond Lingual Retainer composite	20 Sec

[Table/Fig-2]: Materials application methods

[Table/Fig-3]: Method to section the samples parallel to the lingual retainer wire **[Table/Fig-4a]:** Direct measurement of the length of the penetrated dye at enamel-composite interface. Note the wire is not yet removed **[Table/Fig-4b]:** Direct measurement of the length of the penetrated dye at wire-composite interface after removal of the wire

At the enamel-composite interface, all the materials, irrespective of the wire used performed well with little or no microleakage. The difference was not statistically significant. At the wire-composite interface however, the flexible multistranded wire showed less microleakage when compared to the HRSS wires [Table/Fig-9a, b]. This reduced microleakage was evident when Concise and Transbond XT was used to bond the wires. When Transbond LR is used, the amount of microleakage was low with both the wires and there was no statistically significant difference between the two wires [Table/Fig-9a,b].

DISCUSSION

In orthodontics, various devices for post treatment retention have evolved from conventional, removable wire retainers to esthetic, more hygienic, permanent or semi-permanent bonded lingual retainers, which are designed to serve in the mouth for a long period of time. Many in vitro studies [9,14,19] have suggested that Concise Orthodontic is a preferred composite resin for lingual retainer fabrication because greater force is required to detach the wire from the material and the material has good in vitro abrasion resistance [11]. Transbond LR, a highly filled and a specially manufactured light cure composite for lingual retainers is also recommended for use when longevity and durability is required [12]. It has been shown that Concise Orthodontic and Transbond XT, compares favorably because of its abrasion resistance and strength [11]. The microleakage was assessed with the help of dye penetration method which involves exposure of samples to a dye solution [8,10,18,20] and then viewing cross sections under stereomicroscope [21]. Because of the range of bacteria sizes, dye used was 0.5% Basic fuchsine solution as it is realistic agent to identify a clinically relevant gap [22]. It was determined by direct measurement using an electronic digital caliper of accuracy 0.01mm [8,10,18,20].

At the enamel-composite as well as wire-composite interface and utilizing the 0.036" HRSS wire the microleakage seen in Transbond LR was significantly lower than that of Concise Orthodontic and

		(Group I) Concise Orthodontic		(Group II) Transbond XT		(Group III) Transbond LR	
		0.036" SS wire* sandblasted at ends (a)	0.0175" Coaxial wire (b)	0.036" SS wire* sandblasted at ends (a)	0.0175" Coaxial wire (b)	0.036" SS wire* sandblasted at ends (a)	0.0175" Coaxial wire (b)
Mesial	E-C interface	0.99±0.22	0.99±0.22	0.98± 0.22	0.95±0.22	0.97± 0.22	0.97 ±0.22
	W-C interface	0.88 ±0.22	0.98±0.22	0.94± 0.22	0.98±0.22	0.97± 0.22	0.99± 0.22
Distal	E-C interface	0.99 ±0.22	0.99±0.22	0.95± 0.23	0.89±0.22	0.96 ±0.22	0.96± 0.22
	W-C interface	0.99± 0.22	-	0.96± 0.22	-	0.96±0.22	-

[Table/Fig-5]: Inter examiner Kappa scores for assessment of micro-leakage amongst three composites using 0.036" Hard Round Stainless Steel Wire* and 0.0175" coaxial wire

			0.036" SS wire sandblasted at the ends				0.0175 Coaxial Wire			
			Mean	Std.Dev.	Minimum	Maximum	Mean	Std.Dev.	Minimum	Maximum
Group I (Concise Orthodontic)	E- C interface	Mesial	0.94	0.44	0.58	1.86	0.98	0.41	0.4	1.83
		Distal	0.14	0.38	0	1.23	0.09	0.08	0	0.27
	W-C interface	Mesial	1.04	0.36	0.46	1.66	0.89	0.26	0.66	1.65
		Distal	0.28	0.37	0	0.96	0	0	0	0
Group II (Transbond XT)	E- C interface	Mesial	1.32	0.34	0.37	1.9	1.29	0.25	0.65	1.68
		Distal	0.26	0.38	0.06	1.36	0.12	0.29	0	0.9
	W-C interface	Mesial	1.32	0.26	0.88	1.77	1.07	0.35	0.35	1.65
		Distal	0.53	0.22	0	0.9	0	0	0	0
Group III (Transbond LR)	E- C interface	Mesial	0.61	0.39	0.66	1.74	0.67	0.38	0.13	1.21
		Distal	0.03	0.11	0	0.51	0.02	0.06	0	0.25
	W-C interface	Mesial	0.73	0.26	0.36	1.25	0.63	0.31	0.11	1.22
		Distal	0.05	0.14	0	0.56	0	0	0	0

[Table/Fig-6]: Microleakage values for 0.036" Hard Round Stainless Steel Wire and 0.0175" coaxial wire in different groups

Wire	Inteface	Surface	Composites	Means	Std.Dev.	Sum of ranks	H-value	p-value
0.036” HRSS	Enamel-Composite	Mesial	Group Ia (Concise Orthodontic)	0.94	0.44	604.5	23.2978	0.0429*
			Group IIa (Transbond XT)	1.32	0.34	675.5		
			GroupIIIa (Transbond LR)	0.61	0.39	550		
		Distal	Group Ia(Concise Orthodontic)	0.14	0.38	757	35.4607	0.0000*
			Group IIa (Transbond XT)	0.26	0.38	534		
			GroupIIIa (Transbond LR)	0.03	0.11	239		
	Wire-Composite	Mesial	Group Ia (Concise orthodontic)	1.04	0.36	556	25.0656	0.0000*
			Group IIa (Transbond XT)	1.32	0.26	831		
			Group IIIa (Transbond LR)	0.73	0.26	300		
		Distal	Group Ia (Concise orthodontic)	0.28	0.37	592	21.7255	0.0000*
			Group IIa (Transbond XT)	0.53	0.22	857.5		
			Group IIIa (Transbond LR)	0.05	0.14	380.5		
0.0175 inch coaxial wire	Enamel-Composite	Mesial	Group Ib(Concise Orthodontic)	0.98	0.41	547.5	15.1177	0.0005*
			Group IIb (Transbond XT)	1.29	0.25	849		
			Group IIIb (Transbond LR)	0.67	0.38	469.5		
		Distal	Group Ib(Concise Orthodontic)	0.09	0.08	785.5	11.1938	0.0037*
			Group IIb (Transbond XT)	0.12	0.29	534		
			Group IIIb (Transbond LR)	0.02	0.06	510.5		
	Wire-Composite	Mesial	Group Ib (Concise Orthodontic)	0.89	0.26	620.5	14.9433	0.0006*
			Group IIb (Transbond XT)	1.07	0.35	818		
			Group IIIb (Transbond LR)	0.63	0.31	391.5		
		Distal	Group Ib (Concise Orthodontic)	0	0	610	0	1
			Group IIb (Transbond XT)	0	0	610		
			Group IIIb (Transbond LR)	0	0	610		

[Table /Fig-7]: Comparison of microleakage with respect to three composites at wire composite interface on mesial and distal sides by Kruskal Wallis-ANOVA test

Interface	Surface	Composite	Wires	Sum of ranks	U-value	Z-value	p-value
Enamel-composite interface	Mesial	Group I(Concise Orthodontic)	HRSS	378	112	-0.6804	0.3621
			M	322			
		Group II (Transbond XT)	HRSS	437	173	-0.7304	0.4652
			M	383			
		Group III (Transbond LR)	HRSS	541.5	68.5	-1.5571	0.5732
			M	498.5			
	Distal	Group I(Concise Orthodontic)	HRSS	351	33	-0.6975	0.3721
			M	302			
		Group II (Transbond XT)	HRSS	386	24	-0.7608	0.5221
			M	334			
		Group III (Transbond LR)	HRSS	409.5	187.5	-0.0135	0.7892
			M	378.5			
Wire-composite interface	Mesial	Group I(Concise Orthodontic)	HRSS	503.5	106.5	-2.5292	0.0114*
			M	316.5			
		Group II (Transbond XT)	HRSS	499	111	-2.4075	0.0161*
			M	321			
		Group III (Transbond LR)	HRSS	446.5	163.5	-0.9873	0.3235
			M	373.5			
	Distal	Group I(Concise Orthodontic)	HRSS	490	120	-2.164	0.0305*
			M	330			
		Group II (Transbond XT)	HRSS	590	20	-4.869	0.0000*
			M	230			
		Group III (Transbond LR)	HRSS	440	170	-0.8115	0.4171
			M	380			

[Table/Fig-8]: Comparison of microleakage with respect to 0.036” Hard Round Stainless Steel wire* *and* 0.0175” multistranded wire£ *at* enamel composite interface *by* Mann-Whitney U test

Transbond XT. This decrease in microleakage could probably be attributed to the filler loading of the resin [15]. Transbond LR is claimed to have a filler load of 75-85% [15], Concise 80%, [19] Transbond XT 70-80% [15]. The filler particle size and the load is seen to influence the polymerisation shrinkage of material and this could influence the microleakage [15]. These values of microleakage were consistently higher on the mesial side as against the distal side and this could probably be attributed to the presence of thick round wire and its related difficulty of forming the composite as smooth as the distal portion. This view is in accordance with Uysal [20]. The microleakage values were not in agreement with that obtained by Uysal et al,. [20], Baysal et al., [10] and Yagci et al., [18]. These variations suggest the importance of other factors, such as study design, difference in pretreatment of wire before bonding to lingual surface of teeth, different methods of enamel pretreatment in determining microleakage.

According to this study, Concise Orthodontic proved to be a material superior to Transbond XT owing to the reduced marginal leakage. Concise Orthodontic is chemically cured and where increased working time through light curing is preferred, Transbond XT is a viable option. Polymerization shrinkage is one important factor to be considered and it could be a cause for failure of fixed lingual retainers (detachment at wire-composite interface) [15,21]. At the enamel-composite as well as wire-composite interface and utilizing the 0.0175" multistranded wire, the pairwise comparison of microleakage values of the three groups revealed Transbond LR to have a significantly lesser microleakage than Transbond XT and Concise Orthodontic. For the 0.0175" multistranded wire, microleakage values at the enamel-composite interface and wire-composite interface were more or less equal. When the two wires were compared to each other with respect to the three composite resins, it was noted that the multistranded wire performed better than the stiff 0.036 inch HRSS wire with regard to microleakage. Hence, as a result of this study, with respect to microleakage, Transbond LR has got reduced polymerization shrinkage and consequent microleakage. This is in accordance with Uysal et al., [8].

Foek et al., [23] studied the bond strength of a stainless steel orthodontic wire vs various fiber-reinforced composites (FRC) used as orthodontic retainers on enamel and confirmed that regardless of application mode, stainless steel orthodontic bonded retainers delivered higher bond strengths than those of fiber retainers. Intensity of the different curing light should also be taken into consideration as high-intensity light curing units show statistically significant microleakage at the composite/wire interface and therefore may not be safe for use in bonding for lingual retainer wires [24]. The limitation of the study are: (1) the oral environmental conditions cannot be simulated outside accurately to examine the micro-leakage, (2) Chances of damaging the stained areas while sectioning the teeth, (3) Application mode and the flow of the materials tested are different and may influence the micro-leakage values.

CONCLUSION

Transbond LR in combination with 0.0175 inch multistranded wire showed least microleakage amongst all wire-composite combinations studied.

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