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Micro-leakage around orthodontic brackets with direct and indirect bonding

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Abstract

Introduction: It is essential to obtain a reliable adhesive bond between an orthodontic attachment and tooth enamel. All brackets exhibit micro leakage and its in the best interest of the patient to have minimal iatrogenic effects of this micro-leakage. Hence the objective of this study was to compare the microleakage under and around orthodontic brackets bonded with direct and indirect bonding technique.

Material and Methods: Sixty human premolars were collected. Microleakage scores were directly recorded, using an electronic digital caliper (Guang Lu,China). For each section, there were two sides to be evaluated (incisal-gingival or mesial-distal) and each side had two interfaces to the score (enamel-adhesive and adhesive-bracket). Four parallel longitudinal sections were taken through the occlusal and gingival surfaces with a low-speed diamond saw in the bucco-lingual direction

Results: This study showed that although microleakage values are slightly different (0.0988mm and 0.0916mm in direct and indirect bonding respectively) between the two bonding techniques, but this was insignificant. Similarly, the bracket to adhesive interface showed higher microleakage depth in both groups as compared to adhesive enamel interface. The gingival sites of all the tooth sections showed higher microleakage as compared to the incisal sites.

Conclusions: No significant difference of micro-leakage existed around and under bracket when bonded with different techniques.

Keywords: Orthodontic bonding; enamel fracture; iatrogenic effects of orthodontic treatment

Introduction

In routine orthodontic practice, it is essential to obtain a reliable adhesive bond between an orthodontic attachment and tooth enamel.[1] In order to apply forces to a tooth, brackets are bonded to the smooth surfaces. This is done mainly by two methods comprising of direct and indirect bonding. Indirect bonding was first introduced in orthodontics by Silverman[2] in an effort to place bracket more accurately and efficiently. This technique has more accuracy; less chair side time but greater lab dependence and has been modified by Sondhi.[3,4]

All brackets exhibit some amount of micro-leakage regardless of the adhesive and bracket type.[5] Orthodontic adhesive layers are very thin and the free floating bracket is pulled closer to the enamel surface by the composite shrinkage. From the orthodontic point of view, microleakage can be defined as a factor explaining the formation of white spot lesions at the adhesive and enamel interface.[6] Microleakage beneath orthodontic brackets can have severe consequences such as enamel decalcification, enamel discoloration, corrosion and decreased bond strength.[7] It is well documented that microleakage increases the likelihood of recurrent caries and post-operative sensitivity.[8]

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Various innovations have popularized in adhesive technologies which are replacing conventional methods to save time and conserve tooth material. Although, advantages are revolutionary but a significant caries risk under and in the vicinity of bracket is of concern. The polymerization shrinkage of composite materials may lead to gaps between adhesive and enamel surface, which causes shrinkage, staining and eventually lead to micro-leakage. This can facilitate formation of white spot lesions under the bracket.[9]

Microleakage shows higher scores on gingival sides in comparison to occlusal side.[10] It was assumed that these differences are due to the curvature of the tooth crown that may result in relatively thicker composite at the gingival margin. It was also concluded that lesser micro-leakage should occur at occlusal than gingival side and might be related to the curing method.[1,5,11]

There is scarcity in literature regarding comparison of micro-leakage when the brackets are bonded via direct or indirect method. Hence the aim of this in-vitro study was to compare microleakage of orthodontic brackets around and between the enamel – composite and composite – bracket interfaces at the incisal and gingival margins. Comparison was made between indirect bonding and conventional direct bonding methodology.

Material and Methods:

Sixty human premolars extracted for orthodontic reasons were collected. The extracted teeth were store in distilled water (For maximum 1 month). The specimens were randomly assigned to two equal groups named A and B (30 each) on the basis of the bonding procedure. Immediately before bonding, the teeth were cleaned with a scaler and pumiced in order to remove soft tissue remnants, calculus and plaque.

Teeth of Group A were bonded directly by applying composite after etching and conditioning of enamel surface. Teeth of B group were bonded indirectly with composite Sondhi Rapid Set A/B Primer (3M-Unitek, filled resin primer). Before bonding the indirect samples, group of ten teeth were attached to a 0.040 inch stainless steel wire with sticky wax so that inter-proximal surfaces of adjacent teeth were in contact.

The wire was pre-bent to an approximate Dentec arch form (Daub et al, 2006). A similar arch form template of boxing wax was luted to a flat surface and the wire with the attached teeth was balanced on the top edge of the boxing wax template. The teeth were then mounted in cold cure acrylic. An alginate impression was made of the mounted teeth and poured in orthodontic stone. The working models were allowed to set overnight and a layer of cold mold seal was applied as a separating medium (diluted with water in 1:1 ratio) and allowed to dry for 20 minutes. The brackets were placed on the working models with Transbond XT composite and the excess resin was removed with a hand instrument.

The brackets were then placed on models with composite and cured with LED light for 20 sec from all sides to ensure maximum polymerization. A transfer tray was fabricated using a Biostar unit to vacuum form a 1 mm thick layer of Bioplast, overlaid with a 1 mm thick layer of Biocryl. The transfer tray was carefully removed from the working model and placed back into the Triad machine for 1 minute with the bracket bases facing the light source. The bracket bases were scrubbed with a toothbrush under running water and blown dry with oil-free air.

The enamel in group 2 was prepared as for group 1. While the liquid primer Transbond XT applied to the etched surface in group 1, the Sondhi Rapid Set Primer was used in group 2. After etching and drying the teeth as described above, a thin layer of Sondhi Rapid Set Primer A was painted on each tooth and a thin layer of Sondhi Rapid Set Resin B was painted on the custom adhesive base of each bracket. The transfer tray was placed and held with finger pressure for 30 seconds and then left on the teeth without any pressure for 2 minutes. The bonding process comprised of A applied on tooth surface and B on the bracket surface. All this information was recorded on a pre-designed proforma. Measurement of microleakage was done by the researcher herself.

The teeth were immersed in a 0.5% solution of basic fuchsine for 24 hours at room temperature. After removal from the solution, superficial dye was removed with a brush and dried. For micro-leakage measurement, nail varnish was applied to the whole surface of the teeth except 1 mm from the margins which were supposed to be examined.

These were kept in distilled water as soon as the nail polish dried in order to prevent dehydration of the samples before dye penetration.

They were embedded in epoxy resin (Heraeus kulzer, Germany) blocks; the impression for the blocks was prepared, using a polyvinyl siloxane impression material (Speedex Putty/ Coltene) with an index to place the samples properly in acrylic. The samples were set in the acrylic blocks according to the proposed direction of the sections. Each acrylic block had the index to determine the position of the disc for sectioning. The cutting was carried out with a low-speed diamond saw (Auccutom-50, Struers, Denmark). All samples were numbered before sectioning according to their groups and randomly examined by one investigator under a stereomicroscope (Miotic, China) at standard magnification (X 40) in a blinded fashion.

Microleakage scores were directly recorded, using an electronic digital caliper (Guang Lu,China) twice by one observer and the data were recorded. For each section, there were two sides to be evaluated (incisal-gingival or mesial-distal) and each side had two interfaces to the score (enamel-adhesive and adhesive-bracket). Four parallel longitudinal sections were taken through the occlusal and gingival surfaces with a low-speed diamond saw in the bucco-lingual direction according to Arhun & fabrolaili.[4]

Each section was scored from both occlusal and gingival margins to the brackets at both enamel–composite and the composite - bracket interface under stereomicroscope and was recorded. Micro-leakage was evaluated by direct measurement using an electronic digital caliper recording the data to the nearest value as a range between 0.5 and 5 mm. Statistical analysis was performed. For each specimen, micro-leakage scores of the gingival and occlusal sides were obtained by calculating the mean microleakage scores of each side measured from four sections. To compare the mean microleakage score of both bonding systems t-test was applied. The level of significance was kept at $p < .05$.

Results

Microleakage measured at incisal site at enamel-adhesive interface were 0.14 ± 0.02 while after

indirect bonding, the measured value was slightly different (0.15 ± 0.019). The values at bracket-adhesive interface with indirect bonding method came out to be 0.16 ± 0.021 while with direct bonding it was measured to be 0.20±.03.

With indirect bonding at gingival site, the micro-leakage was measured to be 0.19 ± 0.02 (at enamel-adhesive interface) and at adhesive-bracket interface, the measured vales were found to be 0.21 ± 0.02, while with direct bonding, the results came out to be 0.14 ± 0.03 and 0.20 ± 0.02 respectively.

Table I : Micro-leakage with direct bonding at gingival and incisal margins

Micro-leakage (mm) Indirect bonding		Minimum	Maximum	Mean	Std. Deviation
	Enamel-adhesive	.11	.19	.1545	.01987
Incisal	Adhesive-bracket	.13	.20	.1645	.02119
Gingival	Enamel-adhesive	.14	.28	.1998	.02972
	Adhesive-brcaket	.15	.27	.2148	.02554

Table II: Micro-leakage with indirect bonding at gingival and incisal margins

Microleakage(mm) direct bonding		Minimum	Maximum	Mean	Std. Deviation
	Enaml-adhesive	.07	.23	.1440	.03499
Gingival	Adhesive-bracket	.16	.29	.2095	.02645
Incisal	Enamal-adhesive	.11	.26	.1973	.02962
	Adhesive-bracket	.14	.27	.2058	.03110

Table III: Comparison of mean of micro-leakage (t-test)

Sites	Interfaces	Bonding	# of teeth	Mean	Std. Deviation	Std. Error Mean	P<.05
Gingival	Enamal adhesive	Direct	60	.1440	.03499	.00452	.000
		Indirect	60	.1998	.02972	.00384	
	Adhesive-bracket	Direct	60	.2095	.02645	.00342	.264
		Indirect	60	.2148	.02554	.00330	
Incisal	Enamel-adhesive	Direct	60	.2058	.03110	.00401	.000
		Indirect	60	.1545	.01987	.00256	
	Adhesive-bracketI	Direct	60	.1973	.02962	.00382	.000
		Indirect	60	.1645	.02119	.00274	

Under the brackets, micro-leakage showed different values when bonded with either method, but this was not significant (Table IV).

Table IV: Comparison of micro-leakage under the bracket with direct and indirect bonding

Bonding	Mean	Std. Deviation	Std. Error Mean	P<.05
Direct	.0988	.01698	.00219	.067
Indirect	.0915	.02563	.00331	.068

With direct bonding, mean values were 0.016 ± 0.002 and with indirect bonding these were 0.02 ± 0.003. After comparing values with the help of independent t-test, the values were not significant.

Hence the hypothesis that indirect bonding showed less microleakage is not proved. Rather there was no significant difference between the two. Similarly bracket-adhesive interface showed higher micro-leakage depth in both groups.

Discussion

The potential of white spot lesion formation around orthodontic brackets has become a particular clinical problem for orthodontic treatment. Adhesive at the edges of the brackets undergoes shrinkage and this shrinkage can pull the bracket closer to the enamel by the free floating phenomenon. James et al were the first to point out the increased risk of decalcification caused by microleakage around orthodontic brackets. Both the area around the brackets and the area under the brackets need attention to determine the risk of caries formation. In the present study, microleakage of the bonded specimens was determined by the dye penetration method, which is one of the most common microleakage assessment methods

According to Uysal et al,[1] gingival sides in all groups exhibited higher microleakage scores compared with those observed on the occlusal sides for both adhesive interfaces. The type of light-curing unit (Halogen, LED, PAC) did not significantly affect the amount of microleakage at the enamel-adhesive-bracket complex. In the present study, gingival site also showed higher microleakage scores as compare to incisal side.

Another experimental study proved that gingival side of all groups exhibited higher microleakage scores than the occlusal sides for both the enamel-adhesive and adhesive bracket interfaces, and some of the differences were statistically significant.[10] The gingival sides in all groups exhibited higher microleakage scores compared with those observed on occlusal sides for both adhesive interfaces. No differences were observed between metallic and ceramic brackets. Using the CA system in orthodontic practice is safer than using Resin Modified Glass Ionomer Cement since they show less microleakage.

A study should be designed to investigate the proper reason for the difference in the amount of microleakage between the gingival and occlusal sides of the orthodontic brackets. We believe polymerization, which starts at the adhesive material close to the light source, will harden in this region and move the free-floating bracket closer to the teeth so that the shrinkage characteristic of the adhesive farther away from the light source will be changed and will lead to more microleakage.

Yagaci et al claimed that the gingival sides of direct bonded brackets displayed a higher microleakage score than the occlusal side at the enamel-composite interface but this was not statistically significant ($P > 0.05$). All occlusal margins in both groups showed no microleakage under orthodontic brackets at the enamel-composite or composite-bracket interfaces. Comparisons of the microleakage scores between the direct and the indirect bonding groups at the enamel-composite and composite-bracket interfaces indicated no statistically significant microleakage differences at the gingival and occlusal margins ($P > 0.05$). The type of bonding method (direct versus indirect) did not significantly affect the amount of microleakage at the enamel-composite-bracket complex.[9]

Ulker revealed that the type of light curing unit did not significantly affect the amount of microleakage at the gingival or occlusal margins of investigated interfaces ($P > .05$). The gingival sides in the LED and PAC groups exhibited higher microleakage scores compared with those observed on occlusal sides for the enamel-adhesive and adhesive-bracket interfaces.[11]

Arhun et al related these differences to the surface curvature anatomy of the used teeth (human premolar) which caused a relatively thicker adhesive at the gingival margins.[5] Ramuglu10 also attributed the lower amount of microleakage on the occlusal side in their study to a relatively thinner adhesive on this side.[10] The most ideal tooth for testing of the bonding properties is the human maxillary central incisors.[12,13]

Microleakage occurred between the adhesive – enamel and bracket – adhesive interfaces in all groups. For the adhesive – enamel surface, a significant difference was observed between group 1 and groups 2 ($P = 0.011$), 3 ($P = 0.002$) and 4 ($P = 0.000$) on the gingival side. Overall, significant differences were observed between group 1 and groups 3 ($P = 0.003$) and 4 ($P = 0.000$). In dental bonding procedures, acid etching was found to result in the least microleakage. Since etching with a laser decreases the risk of caries and is time-saving, it may serve as an alternative to acid etching.[14]

Microleakage mean values are comparable to other studies. Micro-leakage at enamel - adhesive interface is higher as compare to adhesive - bracket interface. This result is comparable to results of Ramaglu[10], Pakshir[6] and Uysal[1] research work.

However, it is impossible to extrapolate the result of an in-vitro study to the actual oral environment, so further studies are necessary to evaluate the correlations among microleakage and shear bond strength among different bonding techniques. This research opens up a new dimension for researchers.

Conclusions

The conclusions of the present study are:

- The gingival sites of all tooth sections showed higher micro-leakage as compared to incisal sites.
- There is no significant difference of microleakage between direct and indirect bonding techniques.

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