

# Microleakage under orthodontic brackets bonded with the custom base indirect bonding technique

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**SUMMARY** The aim of this *in vitro* study was to compare microleakage of orthodontic brackets between enamel–composite and composite–bracket interfaces at the occlusal and gingival margins, bonded using indirect bonding systems with that of a conventional direct bonding method. Forty freshly extracted human maxillary premolar teeth were randomly divided into two groups. In group 1, the brackets were bonded to teeth directly according to the manufacturer's recommendations. Group 2 consisted of 20 teeth bonded indirectly with Transbond XT (3M-Unitek), as the adhesive, and Sondhi Rapid Set A/B Primer (3M-Unitek), a filled resin primer. After bonding, the specimens were further sealed with nail varnish, stained with 0.5 per cent basic fuchsin for 24 hours, sectioned and examined under a stereomicroscope, and scored for microleakage at the enamel–composite and composite–bracket interfaces from both the occlusal and gingival margins. Statistical analyses were performed using Kruskal–Wallis and Mann–Whitney *U*-tests with Bonferroni correction.

The gingival sides of group 1 displayed a higher median 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.

## Introduction

The indirect bonding method was introduced by Silverman *et al.* (1972) to increase the accuracy of bracket placement. By placing the brackets on stone models before transferring to the mouth, orthodontists can visualize the tooth in three dimensions, allowing the brackets to be more precisely positioned on the teeth; this might decrease the need to reposition brackets later in treatment. Indirect bonding has several advantages when compared with the direct method. Accurate placement of brackets improves patient comfort and reduces chair time (Koo *et al.*, 1999; Sondhi, 1999). There are however disadvantages including technique sensitivity, the need for an additional set of impressions, increased laboratory time, and the risk of adhesive leakage to gingival embrasures (Sondhi, 1999).

Sondhi (1999) introduced a new resin with increased viscosity developed specifically for indirect bonding, which was designed to fill in any imperfections and decrease the incidence of bracket drift. It also exhibited a quicker setting time, which required less chair time holding the transfer tray and a minimum of excess resin around brackets after removal of the tray. This method is now used in many orthodontic clinics (Polat *et al.*, 2004).

Previous studies on dental composites have shown that many characteristics of the material, including hardness,

tensile and compressive strength, and flexural modulus may vary when using different methods (e.g. curing mode, bonding technique). The polymerization shrinkage of the composite material may cause gaps between the adhesive and enamel surface and lead to microleakage, thus facilitating the formation of white spot lesions under the bracket (James *et al.*, 2003). Gap formation contributes to microleakage, permitting the passage of bacteria and fluids from the oral cavity (St Georges *et al.*, 2002). It is well documented that microleakage increases the likelihood of recurrent caries and post-operative sensitivity (James *et al.*, 2003).

James *et al.* (2003) investigated the increased risk of decalcification caused by microleakage around orthodontic brackets, while Arhun *et al.* (2006) assessed microleakage of a tooth–adhesive–bracket complex when metallic or ceramic brackets were bonded with a conventional and an antibacterial adhesive. Arhun *et al.* (2006) found that metallic brackets caused more leakage between the adhesive–bracket interface, which may lead to lower clinical shear bond strength and white spot lesions.

Uysal *et al.* (2008) evaluated microleakage under metallic and ceramic brackets bonded with orthodontic self-etching primer (SEP) systems and stated that SEP caused more leakage between the enamel–composite interfaces. Ramoglu

*et al.* (2009) compared microleakage of light-cured resin-modified glass ionomer cement (RMGIC) and conventional composite under orthodontic brackets and found that RMGIC had higher microleakage scores than conventional composites. Furthermore, Uysal *et al.* (2009a) investigated microleakage patterns of conventional glass ionomer cement (GIC), RMGIC, and poly-acid-modified composite (PAMC) for band cementation. They indicated that conventional GIC was associated with more microleakage than RMGIC and PAMC at both the cement–band and cement–enamel interfaces.

Ulker *et al.* (2009) assessed microleakage of a tooth–adhesive–bracket complex when adhesives were cured with high-intensity and conventional quartz–tungsten–halogen (QTH) lights and showed that high-intensity light units did not cause more microleakage than QTH. Uysal *et al.* (2009b) also investigated the effects of high-intensity curing lights on microleakage under orthodontic bands and found that a plasma arc curing light source is associated with more microleakage than a light-emitting diode and QTH at the cement–enamel interface.

No research in the literature has investigated the effect of indirect orthodontic bonding on microleakage under orthodontic brackets. Thus, the aim of this *in vitro* study was to compare microleakage of orthodontic brackets between the enamel–composite and composite–bracket interfaces at the occlusal and gingival margins when bonded with an indirect bonding system compared with a conventional direct bonding method. For the purpose of the present study, the null hypothesis assumed that there were no statistically significant differences between the microleakage of an enamel–composite–bracket complex with the direct or indirect bonding methods.

## Materials and methods

Forty human premolars, extracted for orthodontic reasons with no decay, restorations, or infection, were collected. The extracted teeth were stored in distilled water until use (maximum 1 month). The specimens were randomly assigned to two equal groups 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.

Group 1 was bonded directly according to the manufacturer's recommendations. A 37 per cent phosphoric acid gel (3M-Dental Products, St Paul, Minnesota, USA) was used to etch the 20 premolars for 15 seconds. The teeth were then rinsed with water from a 3-in-1 syringe for 30 seconds and dried with an oil-free air source for 20 seconds. After surface preparation, the liquid primer Transbond XT (3M-Unitek, Monrovia, California, USA) was applied to the etched surface. Standard edgewise metal premolar brackets (slot 0.022 inch; 3M-Unitek) with a base surface area of 12 mm<sup>2</sup> were bonded with Transbond XT (3M-Unitek) composite paste by direct bonding with a standard protocol.

Group 2 comprised 20 teeth bonded indirectly with Transbond XT, as the composite, and Sondhi Rapid Set A/B Primer (3M-Unitek), a filled resin primer. Before bonding the indirect samples, groups of five teeth were attached to a 0.040 inch stainless steel wire with sticky wax so that the interproximal 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 hard orthodontic stone (Snow White Stone, Heraeus Kulzer, Hanau, Germany). The working models were allowed to set overnight, and a layer of Al Cote separating medium (Dentsply Trubyte, York, Pennsylvania, USA) diluted with water at a 1:1 ratio was placed on each model 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 model was then placed into a Triad light curing unit (Dentsply Trubyte) at three angles to the light source and cured for a total of 10 minutes. A transfer tray was fabricated using a Biostar unit (Great Lakes Orthodontics, Tonawanda, New York, USA) to vacuform a 1 mm thick layer of Bioplast (Great Lakes Orthodontics), overlaid with a 1 mm thick layer of Biocryl (Great Lakes Orthodontics). 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 before removal of the tray.

## Microleakage evaluation

Prior to dye penetration, the apices of the teeth were sealed with sticky wax. The teeth were then rinsed in tap water, air-dried, and nail varnish was applied to the entire surface of the tooth except for approximately 1 mm away from the bracket margins. To minimize dehydration of the restorations, the teeth were replaced in water as soon as the nail polish dried. The teeth were immersed in a 0.5 per cent solution of basic fuchsin for 24 hours at room temperature. After removal from the solution, the teeth were rinsed in tap water and the superficial dye was removed with a brush and dried.

Four parallel longitudinal sections were made through the occlusal and gingival surfaces with a low-speed diamond saw (Isomet, Buehler, Lake Bluff, Illinois, USA) in the bucco-lingual direction according to Arhun *et al.* (2006). Each section was scored from both occlusal and gingival margins to the brackets at both the enamel–composite and the composite–bracket interfaces.

Microleakage was determined by direct measurement using an electronic digital calliper (Mitutoyo Miyazaki, Japan) recording the data to the nearest value as a range between 0.5 and 5 mm.

### Statistical analysis

Both enamel–composite and composite–bracket interfaces were investigated at the gingival and occlusal sides. For each specimen, the microleakage scores of the gingival and occlusal sides were obtained by calculating the mean microleakage scores of each side measured from four sections. Statistical analysis was performed using Kruskal–Wallis and Mann–Whitney *U*-tests with Bonferroni correction (Statistical Package for Social Sciences, Version 13.0; SPSS Inc., Chicago, Illinois, USA). The level of significance was set at  $P < 0.05$ .

### Results

Comparisons of the microleakage scores between the occlusal and the gingival sides for the enamel–composite and composite–bracket interfaces of two groups are shown in Table 1. The gingival sides of group 1 displayed higher median microleakage scores than the occlusal side at the enamel–composite interface, but this was not statistically significant ( $P > 0.05$ ). For the occlusal margins in both groups, there was no microleakage under the orthodontic brackets at the enamel–composite or composite–bracket interfaces.

Descriptive values and comparisons of the microleakage scores for the two groups are shown in Table 2. At the enamel–composite interface, the microleakage scores for group 1 were higher than those of group 2; but this was not statistically significant ( $P > 0.05$ ). Statistical comparisons of the microleakage scores between two groups at the enamel–composite and composite–bracket interfaces indicated that the type of bonding method did not significantly affect the amount of microleakage at the gingival or occlusal margins of the enamel–composite and composite–bracket interfaces. Therefore, the null hypothesis could not be rejected.

**Table 1** Comparison of microleakage scores at the occlusal and gingival sides between the two different interfaces for direct and indirect bonding (Mann–Whitney *U*-test with Bonferroni correction).

Bonding type	Interface	N	Occlusal side descriptive values (mm)			Gingival side descriptive values (mm)			Statistical comparison	
			Percentiles			Percentiles				
			25th	50th (median)	75th	25th	50th (median)	75th	P value	
Direct bonding	Enamel–Composite	20	0	0	0	0	0.25	0.75	0.550	NS
	Composite–Bracket	20	0	0	0	0	0	0.25	0.194	NS
Indirect bonding	Enamel–Composite	20	0	0	0	0	0	0.25	0.540	NS
	Composite–Bracket	20	0	0	0	0	0	0.25	0.121	NS

NS, not significant.

**Table 2** Comparison of microleakage scores between the two different bonding techniques at the enamel–composite and composite–bracket interfaces (Kruskal–Wallis test).

Interface	Composite	N	Descriptive values (mm)			Statistical comparison	
			Percentiles				
			25th	50th (median)	75th	P value	
Enamel–Composite	Direct bonding	20	0	0.25	0.375	0.073	NS
	Indirect bonding	20	0	0	0.25		
Composite–Bracket	Direct bonding	20	0	0	0.125	0.892	NS
	Indirect bonding	20	0	0	0.125		

N, sample size; NS, not significant.

## Discussion

Several studies have investigated the bond strength values of orthodontic brackets bonded using the indirect method in comparison with the conventional direct method (Klocke *et al.*, 2003; Polat *et al.*, 2004; Daub *et al.*, 2006; Linn *et al.*, 2006). Klocke *et al.* (2003) noted that both the original and a modification of the technique of Thomas (1979) were able to produce bond strengths similar to direct bonding. Yi *et al.* (2003) also found no significant difference in bond strength between a light-cured, direct-bond control group and the Sondhi method. Polat *et al.* (2004) found no difference in bond strength between the light-cured direct bonded control and the Thermo-Cure protocol, whereas the bond strengths for the Sondhi protocol were significantly lower. Linn *et al.* (2006) reported no statistically significant difference in bond strength between the Sondhi protocol, that is, using light-cured composite (Enlight LV) with a light-cured sealant (Ortho Solo), and a direct bonded light-cured group.

For restorative dentistry, microleakage is a phenomenon of the diffusion of organic or inorganic substances into a tooth through the interface between the restorative material and the tooth structure (De Almeida *et al.*, 2003). Microleakage increases the likelihood of recurrent caries and post-operative sensitivity (Gladwin and Bagby, 2004).

The polymerization shrinkage of the composite material may cause gaps between the composite and enamel interface and lead to microleakage, thus facilitating the formation of white spot lesions under the bracket surface area (James *et al.*, 2003). The potential for white spot lesion formation has been a clinical problem since fixed appliances were used (Zachrisson, 1977).

Several techniques have been introduced to assess microleakage around dental restorations. The easiest and most commonly used method involves exposure of the samples to a dye solution and then viewing cross-sections under a light microscope (Ozturk *et al.*, 2004). To evaluate the relevance of leakage testing, the effective size of oral bacteria must be considered. Because of the range of bacteria sizes, dyes such as methylene blue and fuchsin are realistic agents to identify the presence of a clinically relevant gap (Hanks *et al.*, 1994; Ferrari and Garcia-Godoy, 2002). Dye penetration was chosen for this study because it provided a simple, relatively cost-effective, quantitative and comparable method of evaluating the microleakage of different bracket bonding methods (Yap *et al.*, 1996; Ozturk *et al.*, 2004).

*In vitro*, microleakage is commonly assessed to detect bond failure at the enamel sealant interface through dye penetration. This failure can be due to polymerization shrinkage or different linear coefficients of thermal expansion from hard tooth substances and resin materials (Celiberti and Lussi, 2005). Thermal cycles are widely used to simulate temperature changes in the mouth, generating successive thermal stresses at the tooth-resin interface. Several investigations have indicated that an increase in the

number of thermal cycles is not related to an increase in microleakage of restorations (Bedran-de-Castro *et al.*, 2004; Ulker, 2008). Therefore, thermocycling was not performed in this study.

It is well established that the type of cementing agent used for bonding has a bearing on microleakage (White *et al.*, 1992; Uysal *et al.*, 2008). It is also known that the composition and other characteristics of cementing agents determine the degree of leakage. Composite viscosity has been increased by fumed silica fibre (Sondhi, 1999). Sondhi Rapid Set adhesive contains approximately 5 per cent of a fine particle fumed silica fibre (Sondhi, 1999). Piwowarczyk *et al.* (2007) found that adhesive which contains fumed silica fibre results in smaller microleakage scores. Thus, it was expected that the direct bonding group in the present study would show higher microleakage scores than the indirect bonding group. This expectation was not true.

In the present study, it was observed that microleakage scores at the gingival margins were greater than at the occlusal margins when direct and indirect bonding methods were used between the enamel-composite and the composite-bracket interfaces. Arhun *et al.* (2006) indicated that microleakage scores obtained from the incisal and gingival margins of brackets demonstrated significant differences, implying increased microleakage at the gingival side. They interpreted these differences as being related to the curvature of the tooth anatomy, which may result in relatively thicker composite at the gingival margin. The findings of Uysal *et al.* (2008) and Ulker *et al.* (2009) were similar to those of Arhun *et al.* (2006) but the interpretation was different. They considered that lower or no microleakage scores at the occlusal than at the gingival side may be related to the curing method; as they applied the light from an occlusal direction.

Several studies have reported that indirect inlay composite restorations result in less microleakage than direct composite resins (Milleding, 1992; Hasanreisoglu *et al.*, 1996). The shrinkage produced by the polymerization process inherent in the composite resin is greater for direct insertion in a cavity when the direct technique is used than the shrinkage of the resinous cement layer used to fix the indirect inlay; this resulted in a greater magnitude of stress in the gingival wall, thus facilitating microleakage. Liberman *et al.* (1997) indicated that the indirect procedure resulted in a significant reduction in microleakage when compared with that produced by the semi-direct inlay technique. Alavi and Kianimanesh (2002) stated that, when bonding agents are correctly applied, there is no advantage with the indirect technique in small Class V cavities. From an orthodontic perspective, bonding of brackets is similar to this condition. In the present study, the microleakage scores of the direct bonding group were higher than in the indirect group; but this was not statically significant. The reason for the similar microleakage scores between the direct and indirect group may have been as a result of the use of a thin layer of composite.



## Conclusions

Bonding of brackets by the direct or indirect method did not significantly affect the amount of microleakage at the enamel–composite–bracket complex.

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## References

- Alavi A A, Kianimanesh N 2002 Microleakage of direct and indirect composite restorations with three dentin bonding agents. *Operative Dentistry* 27: 19–24
- Arhun N, Arman A, Cehreli S B, Arikan S, Karabulut E, Gulsahi K 2006 Microleakage beneath ceramic and metal brackets bonded with a conventional and an antibacterial adhesive system. *Angle Orthodontist* 76: 1028–1034
- Bedran-de-Castro A K, Cardoso P E, Ambrosano G M, Pimenta L A 2004 Thermal and mechanical load cycling on microleakage and shear bond strength to dentin. *Operative Dentistry* 29: 42–48
- Celiberti P, Lussi A 2005 Use of a self-etching adhesive on previously etched intact enamel and its effect on sealant microleakage and tag formation. *Journal of Dentistry* 33: 163–171
- Daub J, Berzins D W, Linn B J, Bradley T G 2006 Bond strength of direct and indirect bonded brackets after thermocycling. *Angle Orthodontist* 76: 295–300
- De Almeida J B, Platt J A, Oshida Y, Moore B K, Cochran M A, Eckert G J 2003 Three different methods to evaluate microleakage of packable composites in Class II restorations. *Operative Dentistry* 28: 453–460
- Ferrari M, Garcia-Godoy F 2002 Sealing ability of new generation adhesive restorative materials placed on vital teeth. *American Journal of Dentistry* 15: 117–128
- Gladwin M, Bagby M 2004 *Clinical aspects of dental materials theory, practice, and cases*. Lippincott Williams & Wilkins, Baltimore, pp. 47–57
- Hanks C T, Wataha J C, Parsell R R 1994 Permeability of biological and synthetic molecules through dentine. *Journal of Oral Rehabilitation* 21: 475–487
- Hasanreisoglu U, Sonmez H, Uctasli S, Wilson H J 1996 Microleakage of direct and indirect inlay/onlay systems. *Journal of Oral Rehabilitation* 23: 66–71
- James J W, Miller B H, English J D, Tadlock L P, Buschang P H 2003 Effects of high speed curing devices on shear bond strength and microleakage of orthodontic brackets. *American Journal of Orthodontics and Dentofacial Orthopedics* 123: 555–561
- Klocke A, Shi J, Kahl-Nieke B, Bismayer U 2003 Bond strength with custom base indirect bonding techniques. *Angle Orthodontist* 73: 176–180
- Koo B, Chung C, Vanarsdall R 1999 Comparison of accuracy of bracket placement between direct and indirect bonding techniques. *American Journal of Orthodontics and Dentofacial Orthopedics* 116: 346–351
- Lieberman R, Ben-Amar A, Herteanu L, Judes H 1997 Marginal seal of composite inlays using different polymerization techniques. *Journal of Oral Rehabilitation* 24: 26–29
- Linn B J, Berzins D W, Dhuru V B, Bradley T G 2006 A comparison of bond strength between direct and indirect bonding methods. *Angle Orthodontist* 76: 289–294
- Milleding P 1992 Microleakage of indirect composite inlays: an *in vitro* comparison with the direct technique. *Acta Odontologica Scandinavica* 50: 295–301
- Ozturk N A, Usumez A, Ozturk B, Usumez S 2004 Influence of different light sources on microleakage of Class V composite resin restorations. *Journal of Oral Rehabilitation* 31: 500–504
- Piowarczyk A, Bender R, Ottl P, Lauer H C 2007 Long-term bond between dual-polymerizing cementing agents and human hard dental tissue. *Dental Materials* 23: 211–217
- Polat O, Karaman A I, Buyukyilmaz T 2004 *In vitro* evaluation of shear bond strengths and *in vivo* analysis of bond survival of indirect-bonding resins. *Angle Orthodontist* 74: 405–409
- Ramoglu S I, Uysal T, Ulker M, Ertas H 2009 Microleakage under ceramic and metallic brackets bonded with resin-modified glass ionomer. *Angle Orthodontist* 79: 138–143
- Silverman E, Cohen M, Gianelly A A, Dietz V S 1972 A universal direct bonding system for both metal and plastic brackets. *American Journal of Orthodontics* 62: 236–244
- Sondhi A 1999 Efficient and effective indirect bonding. *American Journal of Orthodontics and Dentofacial Orthopedics* 115: 352–359
- St Georges A J, Wilder Jr D A, Perdigao J, Swift Jr J E 2002 Microleakage of Class V composites using different placement and curing techniques: an *in vitro* study. *American Journal of Dentistry* 15: 244–247
- Thomas R 1979 Indirect bonding: simplicity in action. *Journal of Clinical Orthodontics* 13: 93–106
- Ulker M 2008 Effect of artificial aging on bond strengths to dentin and on resin-dentin interface of self-etch adhesives (Micro tensile, SEM and TEM study). Thesis, University of Selcuk, Konya, Turkey
- Ulker M, Uysal T, Ramoglu S I, Ertas H 2009 Microleakage under orthodontic brackets using high-intensity curing lights. *Angle Orthodontist* 79: 144–149
- Uysal T, Ramoglu S I, Ertas H, Ulker M 2009a Different orthodontic band cements and the microleakage between cement/enamel and cement/band interfaces. *American Journal of Orthodontics and Dentofacial Orthopedics* In press
- Uysal T, Ramoglu S I, Ulker M, Ertas H 2009b Effects of high curing lights on microleakage under orthodontic bands. *American Journal of Orthodontics and Dentofacial Orthopedics* In press
- Uysal T, Ulker M, Ramoglu S I, Ertas H 2008 Microleakage under metallic and ceramic brackets bonded with orthodontic self-etching primer systems. *Angle Orthodontist* 78: 1089–1094
- White S N, Sorensen J A, Kang S K, Caputo A A 1992 Microleakage of new crown and fixed partial denture luting agents. *Journal of Prosthetic Dentistry* 67: 156–161
- Yap A, Stokes A N, Pearson G J 1996 An *in vitro* microleakage study of a new multi-purpose dental adhesive system. *Journal of Oral Rehabilitation* 23: 302–308
- Yi G K, Dunn W J, Taloumis L J 2003 Shear bond strength comparison between direct and indirect bonded orthodontic brackets. *American Journal of Orthodontics and Dentofacial Orthopedics* 124: 577–581
- Zachrisson B U 1977 Clinical experience with direct-bonded orthodontic retainers. *American Journal of Orthodontics* 71: 440–448

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