Original Article

A Comparison of Two Indirect Bonding Adhesives

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Abstract: The aim of this study was to compare and evaluate the clinical failure rates of the chemically cured composite bonding resin Maximum Cure (MC) and the flowable light-cured resin Filtek Flow (FF) when used in an indirect bonding technique. A total of 112 consecutive patients satisfying the selection criteria were assigned to alternating groups in a split-mouth study design. In Group 1, the maxillary right and mandibular left quadrants were indirectly bonded using MC adhesive, whereas the contralateral quadrants were bonded using FF adhesive. In Group 2, the sides bonded were opposite to those in Group 1. One patient was lost from group 1, so the adjacent patient from group 2 was excluded. Over a six-month observation period, all loose brackets were recorded and the data compared with a Wilcoxon signed ranks test. Of the 2468 brackets placed, 36 with the MC adhesive came loose (2.9% failure rate) compared with 30 in the FF group (2.4% failure rate, $P = .95$). In the maxillary arch, 12 brackets from the MC quadrants came loose vs 24 in the FF ($P = .02$). In the mandibular arch, 24 brackets from the MC quadrants came loose during the six-month observation period compared with six from the FF quadrants ($P = .03$). These results suggest that both adhesives examined in this study (MC and FF) were suitable for the indirect bonding of brackets. The failure rates were low for both adhesives, so either could be recommended for clinical use, the choice being dictated more by operator preference. (*Angle Orthod* 2005;75:1019–1023.)

Key Words: Indirect bonding; Clinical trial; Light cured; Chemical cured

INTRODUCTION

Orthodontics is constantly changing and evolving to improve quality and efficiency. After the diagnosis, the quality of care, outcome, and efficiency are influenced by numerous variables including errors in bracket placement, wire bending, wire selection, variations in adhesive thickness, manufacturer tolerances, operator acuity and fatigue, and the ability to accurately monitor treatment.[1]

The advent of direct bonding of orthodontic attachments to the etched enamel surface as first described by Newman[2] was a major advance in orthodontic treatment. In an effort to produce a more accurate and efficient bracket placement system, indirect bonding was developed by Silverman et al.[3] This technique involves a two-stage process of bracket placement in the laboratory on a plaster model and transfer of these attachments to the patient's mouth by means of a tray, where they are bonded to the etched enamel surface.

Over the years, this technique has been refined and variations described as new techniques or materials have become available.[4–9] The technique originated with the brackets being placed on the plaster model with sugar candy, which was later removed and a composite bonding agent placed at the time of bonding.[3] This led to excessive flash and clean up and evolved to the use of custom bases, whereby the brackets are attached to the model with either a chemical-, light-, or thermal-activated composite.[4–6] Once set, only a thin layer of bonding agent was required to bond to the etched enamel producing minimal flash.

Initially, bond failure rates for indirect bonding (13.9%) were higher when compared with direct bonding (2.5%).[10] However, with modifications and improvements to the technique, the two systems now have similar bond strengths and failure rates.[5,11,12]

When using certain types of clear brackets, it has been reported that light-cured custom bases were superior to thermally cured bases.[13] Another study found light-cured bases to be superior on all bracket types, so light-cured bases would be more appropriate as the

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only type of custom base to be used.[14] A technique has been previously described using adhesive-precoated brackets (APC) (3M/Unitek, Monrovia, Calif) providing uniform application of adhesive to the bracket base.[7] This technique has been modified and a new adhesive (Sondhi Rapid Set, 3M/Unitek) has been advocated that was designed specifically for indirect bonding.[9] However, in a clinical comparison of this new adhesive and Maximum Cure (MC) filled resin (Reliance Orthodontic Products, Itasca, Ill), the chemical-cured MC was found to be superior.[15] More recently, a technique has been described using a flowable light-cured adhesive (Filtek Flow, 3M/Unitek) for the indirect bonding of braces using a plasma-arc light for rapid curing.[16]

The purpose of this investigation was to compare and evaluate the clinical performance over six months of a chemically cured composite bonding resin MC with the light-cured resin FF when used in an indirect bonding technique. The null hypothesis was that there was no significant difference in bracket failure rates between MC and FF adhesives when used for indirect bonding.

MATERIALS AND METHODS

Subjects were prospectively selected from the private orthodontic practice of the author (Dr Miles) who had routinely indirect bonded for nine years. Sample size was calculated from the data of a previous study[15] using a power analysis. To reach a power of having an 80% chance of finding a true difference of twice as many failures of one adhesive vs another, 146 subjects would be required for the maxillary assessment and 237 subjects for the mandibular assessment. A total of 112 eligible subjects had been bonded, when some major staff changes occurred in the practice, which would have affected the laboratory and clinical components of the bonding process and so the decision was made to stop adding subjects.

Forty-six patients failed to meet the following selection criteria to participate in the study: (1) 25 did not have all brackets placed in both maxillary and mandibular arches at the same appointment because of a single-arch treatment (19) or severe rotations/unerupted teeth (6), (2) eight had a fixed intermaxillary appliance used (eg, Forsus, 3M/Unitek), however, intermaxillary elastics were acceptable, (3) seven cases were not symmetrical, either having asymmetrical extractions or missing teeth (eg, loss of both upper first or second premolars was acceptable but not loss of upper right first premolar and upper left second premolar), (4) three had facial restorations where brackets were placed, and (5) three laboratory accidents (broken models) prevented manufacture of indirect bonding trays.

Each patient was consecutively assigned to one of two alternating groups. Group 1 had the maxillary right quadrant and mandibular left quadrant from first molar to central incisor indirectly bonded using MC (filler content approximately 12%+) adhesive, whereas the maxillary left and mandibular right quadrants were indirectly bonded using FF (filler content 68% by weight) adhesive. Group 2 had the opposite side of the arch bonded with FF or MC compared with group 1. Some cases had bands fitted on first molars or a restoration was present on the buccal surface, so only the premolars to the incisors were included in the study. The author (Dr Miles) had previously used MC for seven years and FF for two years before commencing the study.

Accurate alginate impressions (Aroma Fine Fast Set, GC International Corp., Tokyo, Japan) were used to fabricate models that were coated with alginate separating medium (Vertex Divosep, Dentimex BV, Zeist, The Netherlands) diluted one part to three parts water. To reduce variability, APC (3M/Unitek) were used and the bracket positioned. Most cases had Clarity (3M/Unitek) brackets placed on the maxillary anterior canine to canine and light-cured with either an ORTHO Lite curing light (3M/Unitek) for four seconds or an Ortholux™ LED (3M/Unitek) for five seconds each, whereas all other teeth had Victory low profile metal brackets (3M/Unitek) placed and cured for 20 seconds to create custom bases. Some cases had both arches bonded with Clarity at the patient's request.

A 1.5-mm (0.06 inch) clear mouthguard material (Henry Schein Inc, Melville, NY) was vacuum formed over the brackets and model. A thin coat of CRC 808 silicone spray (CRC Industries (Australia) Pty Ltd, Sydney, Australia) was sprayed over the inner tray and a second 1.5-mm clear splint material (Henry Schein Inc) was vacuum formed to hold the tray and brackets stationary when placed in the mouth with the MC adhesive. After soaking in water for 30 minutes, the trays were removed with the brackets trapped within the mouthguard material. The trays and brackets were thoroughly dried and the inner mouthguard material tray was trimmed to extend only 1 mm beyond the gingival margin, whereas the rigid outer tray was trimmed to only just cover the gingival aspect of each bracket on the facial aspect. Each bracket custom base was lightly microetched with 110 μm aluminum oxide particles (Korox 110, BEGO, Bremen, Germany) using a microetcher (Danville Engineering, San Ramon, Calif) to remove any adherent plaster or separating medium and then cleaned with liquid household detergent and water for approximately 30 seconds to remove any remaining etchant powder.

To improve adhesion with the bonding agent, 10 minutes before placement of the brackets, the custom base was lightly painted with methyl methacrylate monomer (Dentaurum Orthocryl, Pforzheim, Germany) and air-dried. Teeth were not pumiced before etching, but if plaque was visible, the teeth were brushed with a toothbrush and toothpaste by the operator. The teeth were isolated throughout the bonding procedure with a dry field system saliva evacuator/retraction device (NOLA Specialties Inc, New Orleans, La) and etched for 30 seconds, rinsed and dried for 10 seconds each, and MIP (3M/Unitek), a moisture-insensitive primer, applied. A small amount of FF material was applied to the bracket custom base. The MC resin was then immediately mixed in equal parts with a small dab applied to the custom base and the tooth surface on the contralateral side to the FF material. The lower inner tray with the brackets was then seated and the rigid tray placed over the top of the MC side to hold them still and in position for a minimum of three minutes while the chemical cure took place. The FF side was cured with either the ORTHO Lite or Ortholux™ LED for the time as previously described. The upper trays were then applied in the same manner and held for a minimum of three minutes. The isolating lip and tongue retractors were removed and the rigid trays removed. The lower inner tray was then gently peeled off the lower brackets followed by the upper tray. Any excess flash was removed with a hand-scaler from around the brackets and the occlusion then checked. If the brackets interfered in the occlusion, a composite bite plane or wedge (Herculite XRV, Kerr Corp., Orange, California) was built up on the palatal surface of the maxillary incisors or, if not suitable, on the buccal cusps of the lower molars to disclude any contact with the lower brackets during the initial alignment.

A 0.014 or 0.016 inch thermally active NiTi wire (G&H, Greenwood, Indiana) was placed (size depending on the degree of irregularity) and identical standard instructions regarding care and diet were given. The normal wire sequence used after nine weeks was a 0.018×0.018–inch thermally active NiTi wire (G&H) and after an additional nine weeks, a 0.017×0.017–inch stainless steel wire (G&H) as the final working wire. Any loose brackets were recorded for every patient and these were collated for a six-month period after the brackets were placed. Once a bracket had become dislodged once, it was not included after that time if it came loose again.

RESULTS

A total of 112 patients were included in this study with one drop out from group 1. Therefore, the corresponding adjacent patient from group 2 was excluded to maintain equal numbers. This left a total of 110 subjects (67 females, 43 males, mean age 15.7 years, range 10.8–39.0 years). A total of 2468 brackets were placed, 1234 with each adhesive. Because the data were paired from contralateral quadrants from each patient and the distribution was not normal, statistical analysis involved the use of the Wilcoxon signed ranks test.

A total of 33 brackets came loose from each of group 1 and group 2. Of the brackets placed with MC adhesive, 36 came loose (2.9% failure rate, mean 0.16, 95% CI = 0.08), whereas 30 came loose when using the FF adhesive (2.4% failure rate, mean 0.14, 95% CI = 0.05). This was not statistically significant ($P = .95$). If the first molar brackets were not included, the bracket failure rate was 2.3% for MC and 1.3% for FF.

In the maxillary arch, 12 brackets from the MC quadrants (mean = 0.11, 95% CI = 0.06) came loose vs 24 from the FF (mean 0.22, 95% CI = 0.09, $P = .02$). In the mandibular arch, 24 brackets from the MC quadrants (mean = 0.22, 95% CI = 0.14) came loose during the six-month observation period compared with six from the FF quadrants (mean = 0.05, 95% CI = 0.05, $P = .03$). Therefore, the null hypothesis was rejected for each individual arch, with a higher failure rate for FF in the maxillary arch and a higher failure rate for MC in the mandibular arch. However, for the combined data, the null hypothesis was accepted with no significant difference in bracket failure rates between MC and FF adhesives when used for indirect bonding.

DISCUSSION

The failure rates for both adhesives (MC = 2.9%, FF = 2.4%) were in the low end of the range (2.5–13.9%) reported by previous studies on indirect bonding.[5,10,11,13] Comparing this result with a recent study comparing MC with Sondhi Rapid Set, the 2.9% MC failure rate is slightly higher than the 1.4% reported previously.[15] This study included first molar brackets, which the previous study did not. However, if the first molars were excluded, then the failure rate for MC was reduced, but still higher at 2.3%, whereas that for FF was 1.3%. This would suggest that there is a higher failure rate for first molar brackets but overall still a very acceptable clinical bracket failure rate for either of the adhesives when compared with the higher bracket failure rate of Sondhi Rapid Set (9.9%).

The slightly better performance of FF could be related to its higher filler content than MC. This could possibly result in fewer marginal voids, which has been suggested as a possible cause of reduced bond strength.[12] There was a statistically, but not clinically significant, higher failure rate for the MC adhesive when compared with the FF adhesive in the mandibular arch ($P = .03$). In the maxillary arch, this was reversed, with the FF having the higher failure rate ($P = .02$). Because the upper anterior teeth were routinely bonded with Clarity (3M/Unitek) brackets, there is a possibility that the MC is somehow more compatible with this type of brace vs the Victory (3M/Unitek) brackets commonly used in the lower arch.

It has been suggested that moisture contamination has been the chief cause of failure in indirect bonding.[17] Conversely, it has also been suggested that one of the great advantages of indirect bonding is its ability to isolate the teeth from moisture contamination.[5] Because a split-mouth design was used in this study, it seems unlikely that this could have contributed to the higher failure rate in the lower arch for MC adhesive without also affecting the FF adhesive, unless the FF is more moisture resistant than MC. Finally, it may merely be due to normal variation within the sample and not of significance.

It has been stated that the use of composite bite wedges to prevent occlusal interferences on a bracket is seldom recorded in research but potentially could have a significant effect on failure rates when comparing studies.[15] Because a split-mouth design was used in this study, it is unlikely to have affected the outcome. However, it may help explain the lower failure rates (2.4% and 2.9%) for these adhesives when compared with other studies.

Bond failure rates vary between studies and also when comparing direct and indirect bonding methods. Previous studies evaluating indirect bonding have reported failure rates from 4.5%[11] over three months, 6.5%[5] over six months, to 13.9%[10] over six months. None of these studies reported the use of bite wedges or other forms of occlusal protection of the brackets. The only study to report this detail compared MC and Sondhi Rapid Set and reported a low bracket failure rate of only 1.4% for MC but 9.9% for the Sondhi Rapid Set.[15] The use of bite wedges may therefore reduce the failure rates but is not likely to affect any observed pattern of differences, only their magnitude.

Previous studies, examining MC and the Sondhi adhesive, used brackets with individually applied composite (Light Bond—Reliance Orthodontic Products) to make the custom bases, whereas this study used APC brackets. There may be a better adhesion between Light Bond composite and the MC adhesive than between the APC composite and the MC adhesive. This may explain the slightly higher failure rate (2.9%) for the MC adhesive in this study when compared with the previous report (1.4%). However, the excellent clinical result for all adhesive-custom base combinations over the six months of this and the previous study indicates all are suitable for indirect bonding. Bracket type and base area can affect bond failure. In this study, bracket type did vary in some (all Clarity vs Clarity and Victory brackets). However, with the split-mouth study design, bracket type and base area is unlikely to have influenced the observed pattern of failures.

The author placing the brackets (Dr Miles) had been using MC adhesive when indirect bonding for seven years and FF adhesive for only two years before this study. This difference in experience with each material may have an effect on the results. Because all bonding was performed by the same operator, these results are not transferable to other operators who may experience different success rates. However, the pattern of similar failure rates for both adhesives would still be anticipated.

CONCLUSIONS

- Both chemically cured adhesives (FF and MC) examined in this study were suitable for the indirect bonding of brackets.
- When comparing the chemical-cured MC adhesive with the light-cured FF, overall, neither adhesive had any significantly higher number of breakages ($P = .95$).

REFERENCES

1. Mah J, Sachdeva R. Computer-assisted orthodontic treatment: the SureSmile process. *Am J Orthod Dentofacial Orthop.* 2001;120:85–87.
2. Newman GV. Epoxy adhesives for orthodontic attachments: a progress report. *Am J Orthod.* 1965;51:901–912.
3. Silverman E, Cohen M, Gianelly AA, Dietz VS. A universal direct bonding system for both metal and plastic brackets. *Am J Orthod.* 1972;62:226–244.
4. Thomas RG. Indirect bonding: simplicity in action. *J Clin Orthod.* 1979;13:93–106.
5. Read MJF, O'Brien KD. A clinical trial of an indirect bonding technique with a visible light-cured adhesive. *Am J Orthod Dentofacial Orthop.* 1990;98:259–262.
6. Sinha PK, Nanda RS, Ghosh J. A thermal-cured, fluoride-releasing indirect bonding system. *J Clin Orthod.* 1995;19:97–100.
7. Cooper RB, Sorenson NA Jr. Indirect bonding with adhesive precoated brackets. *J Clin Orthod.* 1993;27:164–167.
8. Hickham JH. Predictable indirect bonding. *J Clin Orthod.* 1993;27:215–217.
9. Sondhi A. Efficient and effective indirect bonding. *Am J Orthod Dentofacial Orthop.* 1999;115:352–359.
10. Zachrisson BU, Brobakken BO. Clinical comparison of direct versus indirect bonding with different bracket types and adhesives. *Am J Orthod.* 1978;74:62–78.
11. Aguirre MJ, King GJ, Waldron JM. Assessment of bracket placement and bond strength when comparing direct bonding to indirect bonding techniques. *Am J Orthod Dentofacial Orthop.* 1982;82:269–276.
12. Hocevar RA, Vincent HF. Indirect versus direct bonding: bond strength and failure location. *Am J Orthod Dentofacial Orthop.* 1988;94:367–371.

13. Miles PG. A comparison of retention rates of brackets with thermally-cured and light-cured custom bases in indirect bonding procedures. *Aust Orthod J.* 2000;16:115–117.
14. Klocke A, Shi J, Kahl-Nieke B, Bismayer U. Bond strength with custom base indirect bonding techniques. *Angle Orthod.* 2002;73:176–180.
15. Miles PG, Weyant RJ. A clinical comparison of two chemically-cured adhesives used for indirect bonding. *J Orthod.* 2003;30:331–336.
16. Miles PG. Indirect bonding with a flowable light-cured adhesive. *J Clin Orthod.* 2002;36:646–647.
17. Milne JW, Andreasen GF, Jakobsen JR. Bond strength comparison: a simplified indirect technique versus direct placement of brackets. *Am J Orthod Dentofacial Orthop.* 1989;96:8–15.