Aim: To develop a cohesive and complete system for fabricating bonding trays and an effective indirect bonding procedure. Material and Methods: A new resin designed specifically for indirect bonding has been developed. Previous problems with indirect bonding systems, which were partly related to the fact that resins designed for direct bonding had to be used, have been addressed. Conclusion: A cohesive and complete system for fabricating bonding trays and for the indirect bonding procedure is presented. World J Orthod 2001;2:106-114.

The transition from removable to fixed appliances made greater precision in tooth movement possible. However, the initial fixed appliances attached brackets and tubes to the patient's teeth with bands, and there were significant limitations in the degree of accuracy possible with these cemented bands. During the 1970s, two parallel developments had a profound impact on orthodontic treatment with fixed appliances. The development of pretorqued and pre-angled brackets permitted a more sophisticated degree of detail in finishing the occlusion. Further, the development of direct bonding made greater precision in the placement of these preadjusted brackets an achievable goal. It remains possible to move teeth, and to achieve a good orthodontic result, without preadjusted appliances. However, a substantial improvement in both the efficiency and the effectiveness of fixed appliance mechanics can now be achieved with the accurate placement of preadjusted brackets. It has always been important that the finished orthodontic result be esthetically and functionally the achievable optimum, and our enhanced understanding of occlusion and occlusal function has been coupled with the efficient application of biomechanics in the design of increasingly advanced preadjusted edgewise appliances.

DIRECT BONDING

The transition from banded attachments to direct bonded attachments has significantly improved orthodontists’ ability to attain accurate bracket positions. However, with chemically cured bonding resins, working time is fairly limited, and this presents an additional challenge in trying to bond posterior teeth. The introduction of light-cured resins like Transbond (3M Unitek, Monrovia, CA, USA) allows increased working time, thereby permitting significant latitude in positioning the brackets before the resin is cured. Despite this increased flexibility, achieving accurate and consistent bracket positions on posterior teeth continues to present a problem, due to poor access. Since rebonding brackets and tubes on posterior teeth is no easier than bonding them the first time, bracket repositioning is best kept to a minimum. Most clinicians direct bond brackets on anterior teeth and premolars but avoid direct bonding on molars. Indeed, some clinicians prefer to band not only the molars, but also the second premolars.

INDIRECT BONDING

The concept of indirect bonding was first mentioned in the literature during the mid- to late 1970s, and various modifications of the process have been reported. In the initial efforts at indirect bonding, taffy candy was used to position brackets on the teeth, and filled chemically cured resins were employed to...
Advantages of indirect bonding

There are significant advantages to indirect bonding:1-7

1. Bracket placement is accurate
2. Use of the orthodontist's time is optimized.
3. Band fitting on posterior teeth is avoided.
4. Need for separators is eliminated.
5. Ability to bond posterior teeth is improved.
6. Patient comfort and hygiene are improved.

Disadvantages of indirect bonding

1. Indirect bonding is technique sensitive.
2. Additional set of impressions is needed.
3. Posterior attachments are more likely to fail if the patient abuses the appliance by chewing ice, etc.

Previous resins used in indirect bonding

With the increasing popularity of indirect bonding over the past two decades, different methods of bonding the brackets to the teeth have been developed. Initially, brackets were positioned on the casts and the bonding was accomplished with a filled resin. The indirect transfer trays were usually formed with silicone tray materials. The bond strength achieved with filled resins was adequate, but the technique, particularly the clean-up, was difficult. It became apparent that one of the deficiencies in the available systems arose from the fact that all the resins and procedures had been designed for direct bonding and had subsequently been adapted for indirect bonding.

A generous window of working time is an important property in a resin designed for direct bonding. This property has no advantage in indirect bonding, since there is no need for an extended cure time once the tray has been placed in the mouth. Therefore, a resin designed specifically for indirect bonding was needed. After innovation, laboratory testing, and clinical trials, an efficient and effective indirect bonding procedure was created. One benefit of this procedure is that it does not require heating the casts, since a custom base of the bracket is developed with light-cured resin.

ACCURACY IN BRACKET PLACEMENT

Orthodontic appliances are now engineered with increasingly sophisticated computerized design and a vast array of tips, torques, labiolingual offsets, and rotations are available to the clinician. However, some of this precision is lost when brackets are applied to the teeth in an indiscriminate manner.

A number of bracket placement systems have been proposed over the years. To realize the full potential of a preadjusted edgewise appliance, the system for bracket placement must be reliable and consistent. The orthodontist must be prepared to incorporate variations in bracket placement dictated by the malocclusion. The positioning of brackets clearly would be different in treatment of patients with open bites versus patients with deep anterior overbites. Kalange has proposed, for example, that the incisal edges of anterior teeth be recontoured prior to bracket placement.8 It is precisely this sort of variation that maximizes the efficiency of bracket placement with indirect bonding.

DEVELOPING A CUSTOMIZED RESIN BASE

In an effort to determine the best method for preparing a custom resin base, a number of clinical trials were completed. It was the author's finding that light-cured resin is a quick and efficient material for placing brackets on models and for forming a custom resin base. Using adhesive precoated (APC) brackets, contamination is eliminated and laboratory
LABORATORY PROCEDURE

Preparation of the bonding trays by the technician

1. Working casts in orthodontic stone, prepared from accurate alginate impressions, are necessary. Care should be taken to ensure that there is no distortion of the impressions. The working casts should be prepared with careful trimming, removal of bubbles, and filling of small voids. If there are large bubbles or voids, it will affect the fit of the bonding tray (Figs 1a and 1b).

2. A thin layer of diluted Al-Cote (Dentsply International, York, PA, USA) separating medium (1 to 4 with water) should be applied to the model and allowed to dry for approximately 1 hour (Fig 1c).

3. If APC brackets are used, the preoriented brackets may be removed directly from the sealed blister pack and positioned on the individual teeth. The excess adhesive should be removed, and the position of the bracket should be carefully checked with a bracket gauge. If noncoated brackets are used, Transbond XT Light Cure Adhesive should be placed on the mesh pad of individual brackets before they are positioned on the cast (Fig 2).

4. Once all brackets have been placed, a final check of the bracket positions can be completed and the excess resin removed. The casts should be placed in the black plastic box provided with the resin, and left for final approval and positioning by the doctor (Figs 3 and 4).

5. When all the bracket positions have been checked, the maxillary and mandibular casts should be placed in the TRIAD (TRIAD 2000, Dentsply International) curing unit and cured for 10 minutes. Although the resin will cure more quickly, extra time is allowed to ensure complete
curing because the access to light between the plaster cast and the bracket base is limited. The amount of time for light curing is substantially reduced with clear esthetic brackets, and 1 minute of exposure to the light should be adequate (Fig 5). Curing can be done with a chairside light-curing unit if a light chamber is not available.

6. Before forming the indirect bonding trays, a light separating spray should be used to facilitate easy removal of the tray from the brackets. A silicone spray or a light cooking spray, such as Pam (International Home Foods, Parsippany, NJ, USA), may be used. The brackets should be sprayed lightly and for less than 1 second (Fig 6).

7. The indirect bonding trays can now be placed over the brackets. The author uses a Biostar (Great Lakes Orthodontics, Tonawanda, NY, USA) unit to vacuform a 1.5-mm-thick layer of Bioplast (Great Lakes Orthodontics) overlaid with a 0.75-mm-thick layer of Biocryl (Great Lakes Orthodontics). The Bioplast layer is vacuformed onto the cast first, and the excess material is trimmed off (Figs 7a and 7b). The Bioplast surface should be sprayed with a silicone spray or a light cooking spray before the Biocryl is adapted, which will permit easier separation of the two layers. The hard outer shell should be trimmed away from all heights of contour for patient comfort and closer fit, since its purpose is only to permit firm seating of the soft tray. The outer layer provides rigidity to the bonding tray, and the inner layer permits easier removal of the tray (Figs 7c and 7d).

8. When a bonding tray made with a silicone transfer material is used, the Biostar unit is not necessary (Fig 8). A bonding tray can be made with a suitable silicone transfer material. Once the putty has been mixed with the activating agent, a small button of the silicone material can be placed around individual brackets, followed by the placement of the remaining material, which is rolled into the
Fig 7  (a) Cast with first layer of Bioplast. (b) The excess material around the base of the cast being trimmed. (c,d) Occlusal and lateral views of the indirect bonding tray. The hard outer shell of Biocryl provides rigidity to the tray.

Fig 8  (a) Superior view of an indirect bonding tray formed with Express silicone impression material. A putty tray of this kind can be used if a vacuformed tray is not desired or a Biostar is not available. (b) Posterior view of a silicone transfer tray, demonstrating bracket positions and tray trimming around the hooks.

9. The casts are soaked for approximately 1 hour to permit the separating medium to dissolve. This allows easier separation of the bonding trays. The bonding trays are now removed from the casts and should be sectioned off with a bur (Fig 9a). It may be necessary to tease the tray off with a scaler. Any excess material should be trimmed with crown and bridge scissors or a scalpel. Once the bonding trays have been trimmed, they should be placed in the TRIAD unit for an additional minute to ensure that any uncured resin is cured (Fig 9b).

10. The trays should now be cleaned with a dishwashing detergent (eg, Dawn, Proctor & Gamble, Cincinnati, OH, USA) in an ultrasonic cleaner for 10 minutes. The trays are then run through the ultrasonic cleaner, in water only, for an additional 5 minutes. They are then rinsed and dried thoroughly (Fig 10 shows external and internal views of the maxillary bonding tray).
Fig 9  (a) Vacuformed indirect bonding tray is removed from the cast. (b) Trimmed indirect bonding trays in the TRIAD chamber for additional curing. One minute of additional curing is recommended to ensure complete curing of the resin base.

Fig 10 External and internal views of a maxillary bonding tray.

CLINICAL PROCEDURE

Preparing the patient

1. Seat the patient and place a napkin around his neck. The author recommends the use of an anti-sialogogue, such as Sal-Tropine (Hope Pharmaceuticals, Scottsdale, AZ, USA). Patients should be instructed to remove contact lenses when they take the anti-sialogogue tablet. In addition, the orthodontist should be familiar with all contraindications prior to recommending an anti-sialogogue.

2. Pumice all teeth. Explain to the patient that this is one of several procedures in preparation for bonding.

3. Rinse the mouth and suction well with water.

4. Show the bonding trays to the patient and explain the procedure—from taking the impressions to placing the brackets in proper position and forming the tray. It is important to stress the time the orthodontist takes to position the brackets and supervise the entire process. There is significant value in emphasizing the importance of proper bracket placement, and the doctor's input on appliance design, to the patient.

5. If there are bands to fit, this should be done after the indirect bonding procedure has been completed. The resin used in this indirect bonding system has a fast set time, and the band fitting can be started immediately.

Placement of bonding trays

1. Whether the indirect bonding procedure can be completed with a single tray for the entire arch, or whether the tray needs to be sectioned into two segments, is a decision based primarily on the degree of isolation that is feasible. If there is significant crowding and imbrication of the teeth, it may be easier to section the tray. Since the working time with the indirect bonding resin is virtually unlimited, as the adhesive does not need to be mixed, the degree of isolation and ease of tray placement are the determining factors. On rare occasions, it may be advisable to section the tray into thirds, in which case the trays may be sectioned as follows:
   * Teeth 13 to 23 or 33 to 43 (anterior segment)
   * Teeth 14 to 17 or 24 to 27; 34 to 37 or 44 to 47 (posterior segment)
2. Carefully examine the trays for any remaining separator or tray material that may be covering the adhesive custom base on the bracket. Use a microetching unit to lightly sandblast the adhesive custom bases. A fine aluminum oxide particle (50 μm) is recommended. Be careful not to abrade the resin base.

3. If there is any contamination of the adhesive custom bases, especially if you touch them with your fingertips, the trays should be cleaned with a detergent, rinsed, and dried. The application of acetone to adhesive bases is not recommended, since recent research has indicated that this may have a degrading effect on the resin.

4. If the clinician chooses to use a moisture insensitive primer, such as Transbond MIP, on the enamel surface for the indirect bonding procedure, then the air syringe should be used to remove excess moisture. Complete desiccation of the teeth is optional. A liberal coat of Transbond MIP should be painted onto the enamel surface. Air dry for approximately 2 seconds. Light curing of this primer is not necessary for indirect bonding. If Transbond MIP moisture insensitive primer is not used, and the bonding is accomplished with the indirect bonding resin, then all visible moisture should be removed. The etched teeth should have a frosty appearance, and be completely desiccated. If a frosty appearance is not apparent, repeat the etching process for 15 seconds.

10. Small amounts of the Resin A and Resin B liquids should be poured into the wells (Figs 12a and 12b). Take care to keep liquids separate. Resin A can be painted onto the tooth surface with a brush, and Resin B can be painted onto the resin pads in the indirect bonding tray (Figs 12c and 12d).

11. If too much resin has been placed on the enamel, gently remove the excess with a brush. The overall method of painting the resin on the enamel and the custom bases is similar to painting fingernails.

12. Position the tray over the teeth and seat the tray with a hinge motion. With the fingers, apply equal pressure to the occlusal, labial, and buccal surfaces. Hold for a minimum of 30 seconds (Fig 13a). Figure 13b shows the maxillary and mandibular bonding trays in place. Allow 2 more minutes of curing time before removing the trays. Due to the rapid set time of this adhesive, removal of the first tray can begin once the opposing tray is placed (Fig 14). Figure 15 shows the completed appliance placement.

13. Remove the tray by using a scaler to peel the tray from the lingual to buccal. Use extreme care when removing the tray from around bracket wings. Scale the excess resin around the brackets and from the interproximal contacts. Use dental floss to check that all contacts are open.

14. Repeat steps 4 to 13 for the remaining trays.

15. The initial archwire can now be inserted (Fig 16).

RESULTS

This system has been used by thousands of clinicians internationally, and several thousand patients have been treated. Communication with orthodontists who have used this system indicates that the bonding is relatively consistent and efficient. Occasional bond failures do occur, of course, and are usually related to contamination or improper technique. In those cases, it is a simple matter to section the bonding tray, reapply the adhesive, and reseat the brackets.

Bond strength tests have also proved the efficacy of the resin. Bond strength compares favorably with indirect bonding using Concise Enamel Bond (3M Unitek) and Custom IQ (Reliance). Figure 17 (shown on the web edition of the Journal at http://www.quintpub.com) provides important bond strength data. The indirect resin shows substantially greater
Fig 11  (a) Enamel surfaces are etched with a gel etching material in preparation for bonding. (b,c) Enamel is rinsed after removal of the etching gel. Note that the entire arch can be etched and dried to permit bonding of the complete dental arch.

Fig 12  (a,b) Dispensing wells are supplied with the indirect resin. Resin A is applied to the tooth surface and should be placed in the well identified with the tooth icon. Resin B is applied to the bracket base and should be placed in the well with the bracket icon. (c) Resin A is applied to the etched tooth surface. (d) Resin B being applied to the bracket base.

Fig 13  (a) Placement of the bonding tray. (b) Maxillary and mandibular bonding trays in place.

Fig 14  Removal of the outer shell of the mandibular bonding tray. The Biocryl layer will lift off easily if the two layers were separated during laboratory preparation. The soft Bioplast layer is then removed.
bond strength immediately after curing than the other resins, which is of critical importance during tray removal and initial archwire insertion. Although the final bond strength is not significantly different, the clinical efficiency of this resin is enhanced by its higher bond strength at the 5-minute level, since that is when the indirect bonding tray would be removed and the archwire inserted.

CONCLUSION

A new method for effective and efficient indirect bonding of orthodontic brackets has been presented. The custom adhesive bases are easily formed with Transbond XT or APC brackets, and the indirect bonding is accomplished using a resin developed specifically for this purpose. Bond strength has proven to be excellent, and this system for the indirect bonding of complete dental arches, from second molar to second molar, has been used in pediatric, adult, and orthognathic cases.

Bond strength tests have also proved the efficacy of this resin. Although the eventual bond strength is comparable to that of other resins, the clinical efficiency of this resin is greatly enhanced by the higher bond strength developed within the first 2 minutes. Tray removal is therefore possible within 2 minutes, and archwire insertion can be immediate.

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REFERENCES