Evaluation of Proximal Contacts of Posterior Composite Restorations with 4 Placement Techniques

(Évaluation de contacts proximaux de restaurations composites postérieures à l'aide de 4 techniques de mise en place)

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Sommaire

Contexte : *Contrairement à la situation pour les restaurations à l'amalgame, la réalisation de contacts proximaux acceptables avec des restaurations composites postérieures peut s'avérer difficile. Les contacts proximaux qui ne sont pas tout à fait idéaux peuvent causer du foulage alimentaire, ce qui peut provoquer une formation de caries et des problèmes parodontaux.*

Objectif : *Cette étude avait pour but d'évaluer la qualité des contacts proximaux des restaurations composites postérieures effectuées selon 4 techniques de mise en place.*

Méthodes : *Soixante-quinze (75) dents en ivorine montées, atteintes de caries MOD importantes et standardisées ont été divisées en 5 groupes de 15 dents chacune. Les dents de 4 de ces groupes ont été restaurées à l'aide d'un composite, et celles du groupe restant, à l'aide d'un amalgame. Pour la restauration des 4 groupes au composite, on a utilisé la technique classique du coin de bois et de la matrice (Groupe 1), la technique avec un accessoire à embout lumineux (Groupe 2), la technique avec un instrument à main Contact Pro (Groupe 3) et la technique avec des inserts Beta Quartz en céramique (Groupe 4). Toutes les restaurations ont été effectuées dans des conditions cliniques simulées. Les normes d'évaluation des contacts proximaux ont été établies en préparant 4 modèles d'étude dentaires, chaque modèle ayant un type de contact proximal (ouvert, pas suffisamment serré, idéal et trop serré). Toutes les dents restaurées ont été peintes soigneusement avec du vernis à ongles opaque, à l'exception des zones de contact, afin de dissimuler le type de restauration et, par conséquent, d'assurer une évaluation impartiale de la part des évaluateurs. Trois cliniciens expérimentés ont évalué indépendamment la qualité des contacts proximaux de toutes les dents restaurées (un total de 150 contacts) selon les 4 types de contacts exemplifiés par les modèles d'étude dentaires. En cas de désaccord, les cliniciens ont réévalué ensemble le contact visé.*

Résultats : *Parmi les restaurations à l'amalgame, on comptait 5 contacts qui n'étaient pas suffisamment serrés, 20 qui étaient idéaux et 5 qui étaient trop serrés. Le Groupe 1 des restaurations composites avait un total de 25 contacts ouverts et de 5 contacts qui n'étaient pas suffisamment serrés; le Groupe 2 des restaurations composites avait 3 contacts ouverts, 13 contacts qui n'étaient pas suffisamment serrés et 14 qui étaient idéaux; le Groupe 3 des restaurations composites avait 11 contacts qui n'étaient pas suffisamment serrés et 19 qui étaient idéaux; le Groupe 4 des restaurations composites avaient 3 contacts qui n'étaient pas suffisamment serrés et 27 qui étaient idéaux. Aucun des contacts composites n'a été jugé comme étant trop serré.*

Conclusions : *L'utilisation d'inserts (Groupe 4) a eu un taux de contacts proximaux acceptable dans les restaurations composites postérieures, résultat supérieur aux 3 autres techniques de restauration (90 % vs 0 %, 47 % et 63 % pour les Groupes 1, 2 et 3 respectivement).*

Mots clés MeSH : *composite resins; dental restoration, permanent/instrumentation; dental restoration, permanent/methods*

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Cet article a fait l'objet d'une révision par des pairs.

Initial attempts to use resin composites in posterior teeth were reported in the late 1960s and early 1970s,[1,2] but their clinical performance was unsatisfactory at that time because of excessive wear. In the 1970s and 1980s the manufacturers of these materials made serious attempts to overcome this problem. By optimizing filler content and filler size distribution and by improving the chemical formulations, they made dramatic improvements in the wear resistance and strength characteristics of these materials. By the late 1980s the wear problem had been overcome,[3–6] and attempts were being made to improve bonding to dentin.[7,8] These improvements resulted in an increase in the use of resin composites for posterior restorations; however, other problems such as postoperative sensitivity and difficulty in establishing clinically acceptable proximal contacts continued to pose challenges. Polymerization shrinkage of resin composites was identified as one major cause of microleakage and postoperative sensitivity.[9] Methods to overcome polymerization shrinkage were developed, typically through a strategic incremental placement technique that directed shrinkage toward the cavity wall and not away from it. Although these methods helped to reduce postoperative sensitivity, the problem of proximal contacts remained unresolved.

Research has demonstrated the importance of proper proximal contacts for all restorations. For example, positive relationships between type of proximal contact and food impaction and between pocket depth and food impaction were observed in a group of 40 young adult naval recruits in the United States.[10] Because the consistency of resin composites differs from that of amalgam, it is difficult to condense composite restorations against the contact areas of adjacent teeth. Techniques have been developed to achieve better proximal contacts,[11] including the use of special devices to provide more effective tooth separation (such as a spring-action ring in conjunction with a sectional matrix or Elliot separator). However, such devices do not work well with large cavities (for which there is typically excessive clearance between the prepared and adjacent teeth) because their mechanism of action relies on engaging the interproximal embrasure areas against the remaining hard tooth structure to provide the necessary separation. Other techniques have been developed that rely on the operator using a special instrument to apply pressure to the contact area during light curing. These special instruments include transparent cone-shaped light-tip attachments; special hand instruments such as the Contact Pro (Clinical Research Associates, London, Ont.), which has convex prongs for applying lateral force at the contact area during curing;[11] and restoration inserts. Beta Quartz glass-ceramic inserts (Lee Pharmaceuticals Company, South El Monte, Calif.) are formed from a silica-based glass composite that, when heated to specific temperatures, crystallizes to form a microcrystalline ceramic.[12] The surfaces of these inserts are coated with a silane coupling agent to improve bonding with composite materials. Use of these ceramic inserts with composite restorations is an attempt to improve the overall properties of the restoration by incorporating a large ceramic filler particle for the bulk of the restoration, displacing as much of the composite as possible from the volume of the restoration.[12]

The aim of this investigation was to evaluate the proximal contacts of large MOD resin composite restorations made with 4 placement techniques. The techniques were traditional wedge and matrix, use of the light-tip attachment, the Contact Pro hand instrument and the Beta Quartz glass-ceramic insert.

Methods and Materials

An ivorine lower right first molar mounted in a dental study model (Nissin Dental Products, Kyoto, Japan) was prepared with a large MOD cavity with isthmus width greater than half the intercuspal distance and with clearance of contact for both of the adjacent teeth of at least 1.5 mm at each corner (Fig. 1). The pulpal floor depth was 2.5 mm, and the gingival seat was located 0.5 mm above the cementoenamel junction. Seventy-five replicas of this tooth (made by the manufacturer, Kilgore International Inc., Coldwater, Mich.) were divided into 5 equal groups of 15 teeth each, one group for each of 5 restorative techniques. A clinical simulator with manikin head and torso (Kavo, Leutkirch, Germany) was mounted on a dental chair in an operatory set-up. Each tooth was then mounted consecutively in the dental study model and restored by the same operator according to calibrated guidelines. For all 5 restorative techniques, the matrix consisted of large Wizard wedges (Teledyne-Getz, Elk Grove Village, Ill.) along with 0.0015 in. (0.0375 mm) ultra-thin Dixieland Band Getz Contour matrix bands (Prestige Dental Products, Bradford, UK) in a Tofflemire retainer. The contact areas were burnished with a ball burnisher before placement of the restoration to better define and thin out those areas.

One group of teeth was restored with Permite C (Southern Dental Industries GmbH, Cologne, Germany), an admixed amalgam, according to standard techniques, to serve as a control group. The remaining 4 groups were restored with Z100 – Scotchbond Multipurpose Plus combination restorative material (3M Dental, London, Ont.).

For one group of composite restorations (Group 1), a traditional placement technique was used, whereby the material was inserted in increments and no special measures were taken at the contact areas. For the Group 2 restorations, a special cone-shaped attachment (Bisco Dental Products, Schaumburg, Ill.) that connects to the wand of the curing light unit was used to apply pressure to the contact area during curing in the proximal box area. The tip of this attachment was placed in a half-filled but not cured proximal box and was pushed laterally toward the contact of the adjacent tooth before curing was initiated (Fig. 2). After 40 seconds of curing, the light tip was removed and the remainder of the proximal box was filled with composite material. For the Group 3 restorations, a special hand instrument, the Contact Pro, was used. Each end of this instrument has 2 prongs, which fit into the proximal box of a Class II preparation, with a convex surface facing the matrix band. The ends of this instrument are angled at 90° and 45° respectively to enable application of pressure on either the mesial or distal contact areas (Fig. 3). The proximal box was first filled to the level of the pulpal floor and the tip of the Contact Pro hand instrument was placed into the box and pushed laterally toward the contact area. The light-curing tip was placed as close as possible to the instrument tip for the initial 20 seconds of curing. The tip was then gently

Figure 1: *Lower right first molar prepared with a large MOD cavity.*

Figure 2: *Light-tip attachment used to apply pressure against the mesial contact.*

Figure 3: *Contac Pro hand instrument used to apply pressure against the mesial contact area. The proximal box was first partially filled with composite.*

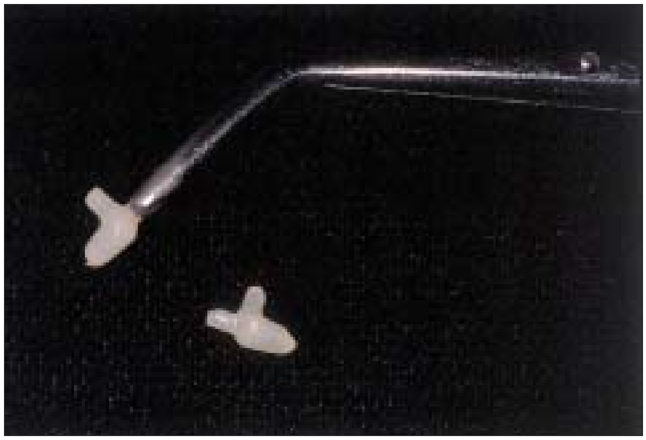

Figure 4: *Beta Quartz glass-ceramic inserts, size L2, one held in a pair of tweezers.*

Figure 5: *A Beta Quartz glass-ceramic insert being pushed against the mesial contact area with a hand instrument. The proximal box was first partially filled with composite.*

Figure 6: *A restored tooth on which the restoration has been concealed with nail polish. The proximal contact areas are not covered with nail polish.*

teased back and forth before being pulled out. An additional 20 seconds of light curing followed before the remainder of the proximal box was restored with more composite material. For the last group of restorations (Group 4), size L2 Beta-Quartz glass-ceramic inserts (Fig. 4) were used to apply pressure at the contact area during curing. The proximal box was first half filled with composite, and an insert held in locking pliers was placed in the box before curing. A hand instrument was used to push the insert snugly against the contact area (Fig. 5). Light curing was then performed as for the Group 3

Table 1 **Assessment of 30 contacts for each restoration technique**

	Assessment of contact; total no. of contacts				
Type of restoration	**Open**	**Not tight enough**	**Ideal**	**Too tight**	**Clinically acceptable[a]**
Amalgam (control)	0	5	20	5	25
Heavy wedging only (Group 1)	25	5	0	0	0
Light-tip attachment (Group 2)	3	13	14	0	14
Contact Pro (Group 3)	0	11	19	0	19
Glass-ceramic insert (Group 4)	0	3	27	0	27

[a]Contacts that were ideal or too tight were considered clinically acceptable (those that were open or not tight enough were considered clinically unacceptable).

restorations. All light curing was accomplished with a Max light (Dentsply, York, Pa.), and composite restorations were trimmed to anatomical shape with rotary instruments.

Four sets of dental study models with a complete set of ivorine teeth were prepared to provide references for assessment of contact quality. In one model, contacts that were too tight at both the mesial and the distal aspects of the lower right first molar were created through addition of a thin layer of a resin composite material to increase the proximal contour of the tooth at the contact areas. For 2 other models, open contacts and contacts that were not tight enough were created at the same locations by using discs to slightly grind the first molar at both the mesial and distal contact areas. In the fourth (ideal) model, no alterations were made to the contact areas.

To conceal the restoration type and hence eliminate the possibility of assessor bias, each restoration was painted with opaque nail polish except in the vicinity of the contact areas (Fig. 6). Three experienced clinicians assessed the quality of the contacts on each restored tooth (mounted in the dentoform and positioned in the simulator on a dental chair as described above). Each assessor used dental floss to independently assess the mesial and distal contacts of each tooth. In cases of disagreement, the 3 clinicians reassessed the disputed contact area collectively and decided on the final assessment by consensus. Contacts that were either open or not tight enough were considered clinically unacceptable.

Results

The control group (restored with amalgam) had a high number of clinically acceptable contacts (25 out of 30) (Table 1); however, the Group 4 restorations (which used Beta Quartz glass-ceramic inserts) had an even higher number of clinically acceptable contacts (27). Five of the clinically acceptable contacts in the amalgam group were too tight, whereas none of the Group 4 contacts were too tight. All 30 contacts in the Group 1 restorations were clinically unacceptable (either open or not tight enough). In this group, large Wizard wedges were used to provide a heavy wedging effect perhaps with some separation between teeth; combined with the use of ultra-thin matrix bands, it was hoped that this method would produce acceptable contacts. The use of the light-tip attachment for Group 2 restorations produced only 14 ideal contacts; the remaining 16 contacts were clinically unacceptable (including 3 open contacts). In Group 3, the Contact Pro hand instrument produced more clinically acceptable contacts (19) than in Group 2, and there were no open contacts. It is interesting that none of the 4 placement techniques for the resin composite resulted in contacts that were too tight (Table 1).

Discussion

Another method of placing composite restorations was attempted in this study. This technique involved a special device (BiTine ring, Darway Inc., San Mateo, Calif.) to apply pressure at the buccal and lingual embrasures to cause some separation between the teeth. However, because of the relatively large clearance at these areas the ring could not be actively engaged between the teeth to cause them to separate, and this technique was not included in the final study protocol. Nevertheless, the authors have had positive results with this technique for small to medium-size cavities. Also, the BiTine ring technique is easier than the inserts technique.

The control group (amalgam restorations) had a high percentage of acceptable contacts (83%). This result was expected because of the positive packing property of the amalgam material. In contrast, when the same technique was used with resin composite (Group 1 composite restorations), all of the contacts were judged clinically unacceptable, in spite of an attempt to minimize the space taken up by the matrix band (through use of ultra-thin bands) and to cause some separation between the teeth (through use of large wedges). However, the simulation set-up used in this study might have been too rigid, in that the ivorine teeth were secured with screws, without any simulation of the periodontal membrane. In the mouth, each tooth has a periodontal membrane, and slight separation of the teeth with heavy wedging is possible. Hellie and others[13] found that the average maximum tooth displacement when a 10-lb (25-kg) force was used to insert a hardwood wedge was 90 µm between maxillary premolars and molars, with a relapse of approximately 30 µm during the first 30 seconds of the wedge being in position. Therefore, perhaps better contacts would have been obtained if this technique had been carried out in the mouth.

Of the 4 composite restoration techniques, the use of inserts (Group 4) yielded the highest number of acceptable contacts. The results for this group were even better than those obtained for the amalgam group. The rigidity of the inserts, the fact that they were used to apply pressure at the contact area and the fact that they became an integral part of the restoration helped in creating clinically acceptable contacts. In Group 2, 47% of the contacts were clinically acceptable, whereas in Group 3 63% of the contacts were clinically acceptable. In Group 2, the special cone tip attached to the curing light tip that was used to apply pressure to the contact area (albeit indirectly through the light-curing gun) may not have been rigid enough to consistently produce clinically acceptable contacts. In Group 3 the Contact Pro hand instrument was of course more rigid than the set-up used for Group 2, and hence the better outcome was not surprising. In addition, the Contact Pro instrument has convex prongs, which simulate physiologic contacts better than does the straight-sided light-tip attachment.

Different methods of assessing the tightness of proximal contacts have been suggested, including visual examination and tactile evaluation by means of dental floss. With the latter method, the tightness of the contact is based on the resistance encountered when the floss is forced through the contact area. Wang and Hong[14] reported a new method for in vivo quantitative evaluation of the proximal contacts of posterior composite restorations by means of a Kaman Sciences KD-2611 noncontact displacement measuring system (Kaman Sciences, Colorado Springs, Colorado). The system uses the principle of variations in resistance in the current field between the sensor head and a conductive nonmagnetic target. As the distance between the target and the sensor changes, the resistance in the current field also changes. However, this elaborate device was used for periodic evaluation of proximal wear of resin composite, rather than for initial evaluation of proximal contacts. Boice and others[15] suggested another method for assessing proximal contacts. They recommended adjusting the proximal contacts until a 0.0005-in. (0.0127 mm) shim stock can pass through the contacts with very slight resistance but 2 shim stocks of the same dimension will hold and not pass. However, the tactile assessment method (with dental floss) was the method of choice for this study because it is the least elaborate and the most clinically relevant.

A more elaborate technique, using ceramic inserts in conjunction with a device, has been developed to achieve clinically acceptable proximal contacts with posterior composites (Sonicsys, Ivoclar Vivadent, Amherst, NY).[16] This method uses ceramic inserts that fit into the proximal box with more precision than the Beta Quartz glass-ceramic inserts. However, there is a substantial difference in cost, and the technique uses special ultrasonic drilling attachments to refine the shape of the proximal box, a process that can be time-consuming. Furthermore, this system is no longer available on the North American market. As an alternative to the Beta Quartz glass-ceramic inserts, similar inserts can be made from a resin composite material in a specially made silicon mold. These work in a fashion similar to the glass-ceramic inserts, with the added advantage that direct chemical bonding to the resin composite restoration is possible (the ceramic inserts rely on a silane coupling agent). Inserts made from a resin composite material will have sufficient rigidity because of their high modulus of elasticity, which is necessary for ensuring clinically acceptable proximal contacts.

Conclusions

Within the limitations of this in vitro investigation and given that Class II cavities were used, 2 main conclusions were reached. First, the ceramic inserts resulted in the highest proportion of acceptable proximal contacts (90%). In contrast, 2 of the 3 other techniques produced acceptable proximal contacts in only 47% and 63% of cases, respectively, and the third technique produced no clinically acceptable contacts. Second, the use of either ceramic inserts or inserts made of a resin composite material should help to ensure acceptable quality of proximal contacts in large resin composite restorations. ✦

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Références

1. Phillips RW, Avery DR, Mehra R, Swartz ML, McCune RJ. One-year observations on a composite resin for Class II restorations. *J Prosthet Dent* 1971; 26(1):68–77.

2. Phillips RW, Avery DR, Mehra R, Swartz ML, McCune RJ. Observations on a composite resin for Class II restorations: three-year report. *J Prosthet Dent* 1973; 30(6):891–7.

3. Wilson NH, Norman RD. Five-year findings of a multiclinical trial for a posterior composite. *J Dent* 1991; 19(3):153–9.

4. Sturdevant JR, Lundeen TF, Sluder TB, Wildes AD, Taylor DF. Five-year study of two light-cured posterior composite resins. *Dent Mater* 1988; 4(3):105–10.

5. Johnson GH, Bales DJ, Gordon GE, Powell LV. Clinical performance of posterior composite resin restorations. *Quintessence Int* 1992; 23(10):705–12.

6. El-Mowafy OM. Wear of posterior composite restorations. A problem of the past. *Ont Dent* 1994; 71(3):13–7.

7. Prati C, Simpson M, Mitchem J, Tao L, Pashley DH. Relationship between bond strength and microleakage measured in the same Class I restorations. *Dent Mater* 1992; 8(1):37–41.

8. Pashley DH. The effects of acid etching on the pulpo-dentin complex. *Oper Dent* 1992; 17(6):229–42.

9. Eick JD, Welch FH: Polymerization shrinkage of composite resins and its possible influence on postoperative sensitivity. *Quintessence Int* 1986; 17(2):103–11.

10. Hancock EB, Mayo CV, Schwab RR, Wirthlin MR. Influence of interdental contacts on periodontal status. *J Periodontol* 1980; 51(8):445–9.

11. Slone CE. New instrumentation and technique for obtaining consistent interproximal contacts of direct Class II composite restorations. *Pract Periodontics Aesthet Dent* 1994; 6(5):15–20.

12. Bowen RL, Eichmiller FC, Marjenhoff WA. Glass ceramic inserts anticipated for 'megafilled' composite restorations. Research moves into the office. *J Am Dent Assoc* 1991; 122(3):71, 73, 75.

13. Hellie CM, Charbeneau GT, Craig RG, Brandau HE. Quantitative evaluation of proximal tooth movement effected by wedging: a pilot study. *J Prosthet Dent* 1985; 53(3):335–41.

14. Wang JC, Hong JM. Quantitative evaluation of proximal contacts in posterior composite restorations. Part I. Methodology. *Kaohsiung J Med* 1989; 5(7):404–8.

15. Boice PA, Niles SM, Dubois LM. Evaluation of proximal contacts with shim stock. *J Oral Rehabil* 1987; 14(1):91–4.

16. Liebenberg WH. Controlling contacts and contours using preformed ceramic inserts. *Compendium Contin Educ Dent* 2000, 21(2):147–50, 152, 154–6.