Minimally invasive management of dental caries

Contemporary teaching of posterior resin-based composite placement in U.S. and Canadian dental schools

Christopher D. Lynch, PhD, BDS, MFD, RCS, FDS (Rest Dent) RCS; Kevin B. Frazier, DMD, EdS; Robert J. McConnell, PhD, BDS, FFD RCS; Igor R. Blum, DDS, PhD, Dr Med Dent, MSc, MFDSRCS(Eng), MFDSRCS(Edin); Nairn H.F. Wilson, PhD, MSc, BDS, FDS, DRD RCsed

Despite advances in public health and preventive dentistry, dental caries still remains a clinically significant oral disease. Perhaps one of the encouraging advances is that practitioners are detecting caries at a much earlier stage of development than they did several decades ago. Challenges for dentists include deciding when to intervene operatively, which preventive measures to apply and which minimally invasive techniques to use to limit the unnecessary removal of healthy tooth tissue. The optimal goal for dentists is to achieve the best possible clinical outcome, both initially and in the long term, with regard to retention of an esthetically pleasing, functional tooth.

A myriad of restorative materials and techniques exist to restore posterior teeth affected by caries. Although indirect techniques, including placement of gold and ceramic-based restorations, are available, they are best suited for teeth requiring larger restorations, in particular those in which one or more cusps are to be protected or replaced. Dentists can use direct techniques with confidence to

ABSTRACT

Background. Resin-based composites are an increasingly popular material for restoring posterior teeth, permitting minimally invasive cavity preparations and esthetic restorations. The authors investigated current teaching of the placement of posterior resin-based composites in U.S. and Canadian dental schools.

Methods. In late 2009 and early 2010, the authors, with the assistance of the Consortium of Operative Dentistry Educators (CODE), invited 67 dental schools to participate in an Internet-based survey.

Results. The response rate was 73 percent. Although all schools taught the placement of resin-based composites in occlusal and most oclusoproximal cavities, eight schools (16 percent) did not teach placement of three-surface oclusoproximal resin-based composite restorations in permanent molars. Resin-based composites accounted for 49 percent of direct posterior restorations placed by dental students in 2009 and 2010, a 30 percent increase from 2005.

Conclusions. Teaching placement of posterior resin-based composites continues to increase in dental schools in the United States and Canada, with predoctoral students gaining, on average, an equal amount of experience placing posterior resin-based composites and amalgams in terms of numbers of restorations.

Clinical Implications. Evidence-based, up-to-date teaching programs, including those in operative dentistry, are needed to best prepare students for careers in dentistry.

Key Words. Operative dentistry; resin-based composites; posterior resin-based composites; dental education; dental students; restorations.

restore teeth with small and moderate-sized preparations, including most teeth requiring multisurface restorations.\(^3\) Popular materials include various forms of glass-ionomer cements, amalgam and resin-based composites. Although glass-ionomer cements have much to offer in terms of adhesion to tooth structure and their fluoride-releasing potential, their modest compressive strength and wear resistance limit their suitability in posterior load-bearing restorations.\(^4\)

Amalgam has been the traditional material of choice for the restoration of posterior teeth with occlusal and oclusoproximal cavities and offers advantages such as ease of placement, low technique sensitivity, good compressive strength and good dissolution resistance.\(^5\) However, some significant disadvantages are associated with amalgam that are not encountered with resin-based composite. These include an unesthetic appearance; a lingering, albeit unfounded, concern among some patients and practitioners about its safety; strict preparation requirements for depth and mechanical retention; and its non-adhesive nature.\(^5,6\)

In contrast, use of resin-based composite allows practitioners to avoid removing healthy tooth structure to achieve retention and resistance form, enabling the procedure to be minimally invasive.\(^2\) Furthermore, predictable techniques exist for the refurbishment or repair of resin-based composite restorations that exhibit signs of deterioration, staining or marginal degradation.\(^7,10\) Such minimally invasive approaches permit localized repair, thereby avoiding the consequences of total restoration replacement, including an inevitable increase in the depth and width of the cavity preparation and an unnecessary challenge to the viability of the pulp-dentin complex. These tooth-friendly features of resin-based composites make them preferable to amalgam, which has provided an invaluable service but which, we believe, now should be considered outdated for use in operative dentistry.

Until recently, practitioners and researchers have judged the suitability of a restorative material according to its mechanical properties and its likely longevity compared with those of another restorative material. Within the past several years, it has become more important to select a restorative material on the basis of the likely life span of the restored tooth, rather than to focus on the potential performance of the restorative material itself. Such an approach is in keeping with a biological, rather than a surgical-mechanical, approach to operative dentistry. Concerns regarding the appropriateness of placing resin-based composites as load-bearing restorations in posterior teeth\(^11\) are viewed increasingly as pertaining to their use as a substitute for amalgam rather than as an alternative material, the placement of which requires a different clinical approach.

In a review article in the late 1990s, Wilson and colleagues\(^1\) recommended that the placement of resin-based composite in posterior load-bearing teeth be “limited to the occlusal surfaces of premolars, and preferably those with limited occlusal function.” Surveys of dental schools’ instruction in posterior resin-based composite placement at about this time revealed that most graduates had little or no clinical experience in placing posterior resin-based composites.\(^12,15\) Since then, researchers have made such enormous advances in all aspects of resin-based composite use in the restoration of posterior teeth that reference to the literature of the 1990s increasingly may be viewed as irrelevant for contemporary practice. This is illustrated by the results of practice-based studies indicating the increased popularity and effectiveness of posterior resin-based composites.\(^16\) These findings show that the performance of resin-based composite restorations now matches, if not exceeds, that of amalgam restorations. Indeed, one could argue that the time has come and gone when there should be debate about the increasing use of resin-based composites. The challenge for practitioners now is to ensure the best use and overall performance of the material today and in the future.

In this article, we attempt to answer this question: given the increasing popularity and predictability of posterior resin-based composites, what is the current teaching of the use of this material, as well as its applications, in U.S. and Canadian dental schools?

**PARTICIPANTS AND METHODS**

In late 2009 and early 2010, we sent an e-mail invitation to 67 dental schools in the United States and Canada; we addressed the correspondence to the person identified as having responsibility for the operative dentistry curriculum, including teaching of the placement of resin-based composites in posterior teeth. We obtained this contact information from the Consortium of Operative Dentistry Educators (CODE) network. We invited them to complete an Internet-based survey (conducted via Bristol Online Surveys, Bristol, England), seeking

**ABBREVIATION KEY. CODE:** Consortium of Operative Dentistry Educators. **LCUs:** Light-curing units. **OP:** Occlusoproximal.
information relating to the teaching of posterior resin-based composite restorations. The survey included questions about the types of restorations; preclinical and clinical teaching, including students’ experience in placing posterior resin-based composites; and clinical techniques taught for the placement of posterior resin-based composites. We advised respondents that the results would be confidential in that no individual schools would be identified in any reports or publications.

The survey included both open-ended questions (that is, respondents were given space in which to write a response to a question) and closed-ended questions (that is, respondents were given a number of possible responses to a question and asked to identify the most appropriate one). We sent two follow-up e-mails to nonrespondents before closing the survey. We analyzed survey responses by using software (Bristol Online Surveys), and we report descriptive results.

RESULTS

We received completed, usable responses from 49 (73 percent) of the 67 invited schools. Table 1 shows the geographical distribution of the respondent schools according to the CODE region. We assumed that the questionnaires were completed by the department chair or by a senior faculty member who had responsibility for the operative dentistry program in the school. We followed up with nonrespondent schools by e-mail at least twice.

**Types of posterior resin-based composites.** All 49 schools responded that they taught the placement of resin-based composite restorations in occlusal cavities in permanent premolars and molars, as well as two-surface occluso-proximal (OP) restorations in premolar teeth. Forty-eight schools reported that they taught the placement of two-surface OP resin-based composites in permanent molars; the one school that did not include this training reported that it would introduce it within the next five years. Regarding three-surface OP resin-based composites, 45 schools and 41 schools, respectively, included this instruction for permanent premolars and molars. Of the four schools that did not teach the placement of three-surface OP resin-based composites in premolars, only one planned to introduce this instruction within the next five years. Similarly, of the eight schools that did not teach the placement of three-surface OP resin-based composites in permanent molars, only one planned to introduce this instruction within the next five years (the same school that reported it would introduce instruction for premolars before 2014 or 2015). The most commonly reported reason for not teaching placement of multisurface resin-based composite restorations in posterior teeth was a preference for indirect resin-based composites in these situations.

**Preclinical teaching.** Thirty-six schools reported that they taught students amalgam placement techniques before they taught posterior resin-based composite techniques; in 12 schools, the order was reversed. Twenty-seven schools anticipated that for the next five years, they would continue teaching amalgam techniques before posterior resin-based composite techniques, while 21 schools anticipated that they would begin teaching placement of posterior resin-based composites before amalgam within that period. (One school did not respond to this question.)

The average amount of preclinical time devoted to teaching placement of amalgam restorations was greater than the time devoted to teaching placement of posterior resin-based composite restorations (mean time for amalgam, 40 percent of preclinical course [range, 5 to 80 percent]; mean time for posterior resin-based composite, 37 percent of preclinical course [range, 10 to 80 percent]). The schools anticipated that, across the next five years, the amount of preclinical time devoted to teaching amalgam placement techniques would decrease, while the time devoted to teaching posterior resin-based composite techniques would increase, such that the resin-based composite to amalgam ratio would be almost 3:2.
Clinical placement. According to the survey responses, an average of 49 percent of posterior intracoronal restorations placed by dental students were resin-based composite (range, 10 to 90 percent) and 48 percent were amalgam (range, 10 to 90 percent). The survey respondents anticipated that within five years, an average of 58 percent of posterior restorations placed by dental students would be resin-based composite (range, 10 to 97 percent) and 37 percent would be amalgam (range, 5 to 90 percent).

Principles of cavity design. In contrast to traditional cavity design features for occlusal and OP amalgam restorations, survey respondents reported that they taught dental students the following techniques for placement of posterior resin-based composite restorations:
- no extension for prevention: 38 schools (78 percent);
- slot-type cavities (that is, no occlusal component): 33 schools (67 percent);
- rounded internal line angles: 31 schools (63 percent);
- beveled box margins: 23 schools (47 percent);
- beveled occlusal margins: four schools (8 percent).

Contraindications. Table 2 lists the contraindications to the placement of posterior resin-based composites, as taught by the responding dental schools.

Moisture control. Thirty-one schools (63 percent) taught dental students that use of a
rubber dam always is necessary when placing posterior resin-based composites, whereas the remaining 18 schools (37 percent) taught students that it was necessary in most situations (approximately 75 percent of cases). In terms of alternative forms of moisture control, 41 schools (84 percent) taught the use of cotton rolls, 36 schools (73 percent) taught the use of dry guards and 12 schools (24 percent) taught the use of gauze. Eight schools (16 percent) did not teach alternative forms of moisture control because, as they noted, there is no alternative to use of a rubber dam.

Operatively exposed dentin. Table 3 shows the techniques taught for the management of operatively exposed dentin before placement of posterior resin-based composites.

<table>
<thead>
<tr>
<th>CAVITY DEPTH</th>
<th>NO. OF DENTAL SCHOOL RESPONDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total-Etch Technique</td>
</tr>
<tr>
<td>Shallow (Outer One-Third of Dentin)</td>
<td>44</td>
</tr>
<tr>
<td>Moderate (Middle One-Third of Dentin)</td>
<td>24</td>
</tr>
<tr>
<td>Deep (Inner One-Third of Dentin)*</td>
<td>6</td>
</tr>
</tbody>
</table>

* Some dental schools reported using more than one technique.

OptiBond Solo Plus (Kerr) in 10 schools and Prime & Bond NT (Dentsply DeTrey) in six schools.

Fourteen schools indicated that they taught dental students the use of flowable resins in their programs. The reported reasons for using flowable resins included gaining stress relief under restorations, using a “snowplow” technique and providing a thin layer in OP cavities when the gingival cavosurface margins extended onto dentin.

Light curing. Respondents from 43 schools reported that they taught students light curing via the use of light-emitting-diode light-curing units (LCUs).

Twenty-five schools taught the use of quartz-tungsten halogen LCUs.

Finishing techniques. Table 4 shows the finishing techniques and instrument use taught, according to the respondents. All 49 schools taught immediate finishing of posterior resin-based composite restorations.

DISCUSSION

An ongoing challenge for dental school programs is that they remain evidence based and up to date with respect to developments and anticipated changes in dental practice. The acceptance by dental schools of the evolving importance of posterior resin-based composite techniques and trends in the use of resin-based composites in general may be viewed as a measure of the adaptiveness and responsiveness of dental school programs to changes in the clinical practice of dentistry.

During the past 20 years, some of us have studied developments in the teaching of posterior resin-based composites. In 1989, instruction in U.S., Canadian and European dental schools mainly was didactic in nature. In some schools (< 10 percent of respondents), students gained mainly preclinical experience in placement of posterior resin-based composite restorations. By the time the next surveys were conducted in 1997 and 1998, little improvement had occurred. Mjör and colleagues surveyed 54 dental schools in North America and found that most dental school graduates had “minimal clinical experience with Class I and Class II composite restorations.” Researchers noted a similar trend in European, Brazilian and Japanese dental schools surveyed at that time. At about this time, however, several impor-
tant events occurred. The American Dental Association published a statement generally endorsing the placement of posterior resin-based composites. In addition, opinion leaders, researchers and clinicians realized that placement of posterior resin-based composites involved less invasive dentistry, and their placement became much more predictable and popular in practice. Researchers and others expressed concern that dental school programs lagged behind trends in clinical practice with respect to use of posterior resin-based composites, with those responsible for teaching operative dentistry in dental schools being out of touch with the needs of recent graduates in terms of their acquiring the skills needed for a key aspect of dental practice. This concern was supported by the results of the 2004 and 2005 surveys, the results of which demonstrated that, although dental students’ experience in placing posterior resin-based composites had increased by almost 200 percent since 1997, the ratio of amalgam to posterior resin-based composites placed by students remained as high as 2:1 in U.S., Canadian, U.K. and Irish dental schools. At the time, survey respondents indicated that the necessary expansion in teaching the use of resin-based composite had been limited in part by outdated payment practices in the United Kingdom, while regional and state dental board examinations continued to emphasize amalgam and other traditional techniques.

In late 2009, we investigated the contemporary teaching of posterior resin-based composites in U.K. and Irish dental schools; the results of our survey showed that students’ experience in placing these restorations had increased by 180 percent during the preceding five years, with a mean of 55 percent of direct posterior intracoronal restorations being resin-based composite. Respondents anticipated that the proportion would increase to 73 percent by 2014. This trend, supported by a consensus statement by the British Association of Teachers of Conservative Dentistry, exceeds the trend reported in U.S. and Canadian dental schools (posterior resin-based composite placement in the present study = 49 percent, 2014 projection = 58 percent), indicating that at least in the area of posterior resin-based composites, dental education in the United States and Canada lags that in the United Kingdom and Ireland, as well as that in other parts of the world.

On the basis of our findings, we suggest that regional and state dental examination boards place an increased emphasis on posterior resin-based composites and that dental schools and organizations such as CODE and the Academy of Operative Dentistry strive to develop evidence-based guidelines that U.S. and Canadian dental schools should adopt to modernize their teaching of operative dentistry with respect to the conservative restoration of posterior teeth, one of the most common procedures in clinical dental practice.

Preclinical teaching. We noted that in 75 percent of schools responding to our survey, students gained experience in amalgam placement techniques before they received training in placement of posterior resin-based composites. This finding is in contrast to the situation in the United Kingdom and Ireland in which the majority of dental schools (63 and 65 percent, respectively) teach placement of posterior resin-based composites before they teach amalgam placement. Instruction in amalgam placement may be limited to techniques used for patients belonging to the so-called heavy-metal generation (that is, those who received often

### TABLE 4

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>NO. OF DENTAL SCHOOL RESPONDENTS (N = 49)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Occlusal Restorations</td>
</tr>
<tr>
<td>Immediate Finishing</td>
<td>49</td>
</tr>
<tr>
<td>Delayed Finishing (&gt; 24 Hours)</td>
<td>0</td>
</tr>
<tr>
<td>Use of Water Cooling</td>
<td>29</td>
</tr>
<tr>
<td>Use of Finishing Diamonds</td>
<td>37</td>
</tr>
<tr>
<td>Use of Finishing Disks</td>
<td>12</td>
</tr>
<tr>
<td>Use of Finishing Strips</td>
<td>37</td>
</tr>
<tr>
<td>Use of Finishing Points</td>
<td>25</td>
</tr>
<tr>
<td>Use of Finishing Pastes</td>
<td>49</td>
</tr>
<tr>
<td>Use of Finishing Stones</td>
<td>23</td>
</tr>
<tr>
<td>Use of Finishing Glaze/ Surface Sealants</td>
<td>25</td>
</tr>
</tbody>
</table>
extensive amalgam restorations in the 1970s and 1980s). The risk in providing instruction in amalgam placement techniques before posterior resin-based composite placement techniques is that students base their approach to operative dentistry on outdated principles. All modern curricula in operative dentistry should be based on a preventive, minimally invasive approach to the treatment of caries, not on mechanical, outdated concepts of treating diseased teeth.

**Cavity preparation.** Twenty-three schools (47 percent) responded that they taught beveling of proximal box cavosurface margins, and four schools (8 percent) taught beveling of occlusal cavosurface margins. Creation of surface occlusal bevels, in contrast to intracrevial beveling in selected occlusal locations, should be discouraged. Placement of bevels along occlusal cavosurface margins results in the creation of thin extensions of resin-based composite (overcontouring) on occlusal surfaces, which may fracture in clinical service and result in marginal defects that may accumulate stain and lead to unnecessary operative intervention. Also, during subsequent refurbishment or repair or eventual replacement of restorations, clinicians probably will encounter difficulties in differentiating between the resin-based composite restoration and adjacent tooth tissue, increasing the risk of unnecessary removal of sound tooth tissue.

The incorporation of bevels along the proximal or gingival aspects of a proximal region is more controversial with regard to the removal of already thin enamel along the gingival margins, with an associated negative effect on the effectiveness of bonding and, in turn, marginal adaption and seal. Although investigators have expressed some concern about achieving effective adaptation of resin-based composite along proximal bevels placed apical to the contact area, some in vitro evidence demonstrates that proximal bevels improve the seal. Further in vivo evidence is required in this area.

**Protection of operatively exposed dentin.** The management of surgically exposed dentin and decisions regarding whether to bond resin-based composites or to use a base, in particular with posterior composites, have been a vexing issue for some time. Although the placement of a protective base may be desirable under an amalgam restoration that exceeds a minimum depth (approximately 2.5 mm), there is little evidence to support the placement of a cement base under resin-based composites, except in the deepest of cavities.

Placement of a cement base under a resin-based composite reduces the available surface area for bonding and typically reduces the mechanical performance of the final restoration. Although some researchers used to consider the placement of a base under a posterior resin-based composite desirable to limit postoperative sensitivity, recent clinical evidence has cast doubt on this approach. Furthermore, recent evidence suggests that the application of phosphoric, rather than polyacrylic, acid to dentin can promote new dentin formation and protect the dental pulp, thus indicating that etching with phosphoric acid and bonding a resin-based composite is more effective than is simply applying a glass-ionomer–type cement base to a resin-based composite.

**Re-creation of proximal contours and contact points.** Müllejeans and colleagues conducted a study in which they demonstrated that use of transparent matrix bands and light-transmitting wedges resulted in significantly higher amounts of excess material at the restoration margins compared with that associated with use of metal matrix bands and wooden wedges. Despite this evidence, nine schools (18 percent) responding to our survey continued to teach the use of such techniques. Evidence shows that the thickness of clear matrix bands likely results in an open proximal contact, as well as problems associated with proximal contour. In addition, the rigidity of plastic light-transmitting wedges increases the risk of proximal overhang formation.

The rationale for use of clear matrix bands, based on outdated theories with respect to shrinkage of composite material relative to application of polymerizing light, appears to persist among some teachers and, in turn, their students. Forty-six (94 percent) of the 49 dental schools responded that they teach the use of sectional metal bands. However, Loomans and colleagues showed that, despite the desirable tightness of proximal contact achieved, these bands were associated with a risk of flash or marginal excess material, which can be difficult to remove at the time of finishing, in particular along gingival margins. This finding highlights the fact that no matrix system is ideal, and that
even the best available matrices must be applied with meticulous attention to detail, including skillful application of a carefully selected wedge, preferably made of wood, to achieve the most favorable adaptation.

Dental schools must ensure that graduating students are best prepared for contemporary clinical practice. It is reasonable to assert that the clinical techniques and philosophies to which dental students are exposed during dental school shape their approach to the treatment of patients in their professional careers. For example, Lynch and colleagues recently conducted a survey of dental students at three European dental schools. The majority of respondents favored the use of posterior resin-based composites over amalgam, but the traditional educational ethos in these dental schools casts doubts on the students' evidence-based approach.

On the basis of the principles of minimally invasive dentistry, resin-based composites have much to offer in terms of preserving tooth tissues, as well as facilitating a preventive approach toward clinicians’ goal of maintaining patients’ teeth for life. When dental students graduate with limited experience in applying the materials they will use most often in the conservative restoration of posterior teeth, it is contrary to the best interests of patients. Furthermore, when the selection of materials for clinical instruction in restoring posterior teeth is evidence based and mindful of trends in clinical practice, it is essential that teachers, in particular those who head departments of operative dentistry, use minimally invasive and evidence-based techniques to apply the materials. Dental school education must be led by research and driven by the quest to apply, through graduates and research discovery, the best available knowledge for the benefit of society. A modern dental school education should not be an apprenticeship in traditional craftsmanship. The history of teaching the placement of posterior resin-based composites in dental schools, including recent findings such as those presented earlier, might serve as the basis of a debate regarding whether dental schools around the world also fulfill their total academic purpose.

CONCLUSION

The results of this study show that teaching the placement of posterior resin-based composites in U.S. and Canadian dental schools has increased since the last survey was conducted in 2004-2005, albeit not as much as in other parts of the world. We suggest that national guidelines pertaining to instruction in placement of posterior resin-based composites, such as those of the British Association for the Teaching of Conservative Dentistry, be developed and adopted to enhance this aspect of teaching in dental schools in the United States and Canada.

Disclosure. None of the authors reported any disclosures.

The authors gratefully acknowledge the assistance of the Consortium of Operative Dentistry Educators (CODE) in facilitating their survey. They also are grateful to colleagues who completed the survey.

21. Wilson NH. Curricular issues changing from amalgam to tooth-