Approximal and occlusal carious lesions

Restorative treatment decisions by California dentists

Peter Rechmann, DMD, PhD; Sophie Doméjean, DDS, PhD; Beate M.T. Rechmann; Richard Kinsel, DDS; John D.B. Featherstone, MSc, PhD

Clinicians increasingly have accepted minimally invasive treatment concepts.1-3 Decisions for restorative treatment have been delayed toward a more advanced carious lesion stage.4 Caries preventive measures are more successful when frequently applied.5,6 Assessing the patient’s caries risk and assigning individualized preventive, nonoperative care measures based on that risk have led to less need for invasive operative treatments.7,8 Classifying carious lesions at a noncavitated stage9 could allow dentists to evaluate whether noninvasive measures would be successful.10 Noncavitated carious lesions in enamel and dentin can be managed by means of remineralization without restorative intervention.11,12 Monitoring topical fluoride application and pit-and-fissure sealants is considered the best practice according to the literature and should become the standard treatment modality for noncavitated carious lesions.13-15 The International Caries Classification and Management System and Caries Management by Risk Assessment recommend minimal intervention treatment according to the patient’s caries risk level.16,17

Surveys in which investigators have evaluated the restorative treatment thresholds of dentists and management strategies have been performed in many countries and reveal wide variations. Those management differences exist among countries and among dentists within each country.18-25

With the background of the success of preventive and noninvasive measures in caries management, we designed this study to determine California (CA) dentists’ restorative threshold for approximal and occlusal lesions by using a Web-based survey. To our knowledge, this is the first time such a study has been performed in CA.

ABSTRACT

Background. Investigators use questionnaire surveys to evaluate treatment philosophies in dental practices. The aim of this study was to evaluate the management strategies California dentists use for approximal and occlusal carious lesions.

Methods. In May 2013, the authors e-mailed a questionnaire that addressed approximal and occlusal carious lesion management (detection and restorative threshold, preferred preparation type, and restorative materials) to 16,960 dentists in California. The authors performed a χ² statistical analysis to investigate the relationship between management strategies and respondent demographic characteristics.

Results. The authors received responses from 1,922 (11.3%) dentists; 42.6% of the respondents would restore approximal lesions at the dentinoenamel junction, and 33.4% would wait until the lesion reached the outer one-third of dentin. The preferred preparation type was the traditional Class II preparation. Dentists who graduated more recently (20 years or less) were more likely to delay approximal restorations (P < .0001); 49.9% of the more recent graduates would wait to restore an occlusal lesion until the outer one-third of dentin was involved, and 42.6% would restore a lesion confined to enamel.

Conclusions. There is wide variety among California dentists regarding their restorative treatment decisions, with most dentists restoring a tooth earlier than the literature would advise. More recent dental graduates were more likely to place their restorative threshold at deeper lesions for approximal carious lesions.

Practical Implications. Clinical evidence shows that noncavitated carious lesions can be remineralized; therefore, early restorative treatment may no longer be necessary or appropriate. Noninvasive and minimally invasive measures should be taken into consideration.

Key Words. Carious lesions; approximal caries; occlusal lesions; diagnosis; decision making; restorative treatment threshold; California dentists.

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TABLE 1

Demographic characteristics of contacted California dentists and respondents.

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>DENTISTS CONTACTED (N = 16,960)</th>
<th>RESPONDENTS (n = 1,842)</th>
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</thead>
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<tr>
<td>Sex, %</td>
<td></td>
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<tr>
<td>Male</td>
<td>68.2</td>
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<tr>
<td>Female</td>
<td>31.8</td>
<td>31.6</td>
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<tr>
<td>Age, y†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (standard deviation)</td>
<td>49.2 (18.0)</td>
<td>50.4 (12.2)</td>
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<tr>
<td>Years Since Graduation‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>1,063 (58.5%)</td>
<td>1,786*</td>
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<tr>
<td>More than 20 y ago</td>
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<td>20 y ago or less</td>
<td>Not applicable</td>
<td>753 (41.5%)</td>
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<tr>
<td>20 y ago or less</td>
<td>Not applicable</td>
<td>1,063 (58.5%)</td>
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<tr>
<td>Type of Practice</td>
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<tr>
<td>General practitioners</td>
<td>14,182 (78.4%)</td>
<td>1,600 (87.5%)</td>
</tr>
<tr>
<td>Specialists</td>
<td>3,896 (21.6%)</td>
<td>229 (12.5%)</td>
</tr>
<tr>
<td>Pediatric dentists</td>
<td>703 (3.9%)</td>
<td>108 (5.9%)</td>
</tr>
</tbody>
</table>

* Total number of respondents to this question.
† At the time of the survey (2013).

METHODS

We obtained approval for the survey study from the Committee on Human Research at University of California, San Francisco (institutional review board approval 12-10135). We sent a Web-based questionnaire electronically (May 2013; including an online consent form) to 16,960 CA-licensed dentists by using SurveyMonkey (SurveyMonkey). We sent an electronic reminder 15 days later. Table 1 provides the demographic characteristics of the dentists contacted.

Espelid and colleagues and Tveit and colleagues designed the questionnaire used in our study, and we used it with their permission (materials reproduced here permission of the publisher). After users provided electronic consent, the Web-based questionnaire assessed the stage of lesion progression at which the respondents considered restorative strategies appropriate by using diagrams of different stages of approximal and occlusal carious lesions. The survey recorded preferred restorative technique and restorative material of choice for treatment of these hypothetical lesions, along with the sex, age, year of graduation, and type of practice (general practitioner [GP] or specialist and the specialty).

For all questions, an imaginary 20-year-old patient was described. This patient visits a dentist annually, has low caries activity and good oral hygiene, and uses a fluoridated toothpaste. The items of the questionnaire are shown in the box and Figures 1-4.

Survey*

APPROXIMAL LESION (FIGURE 1)†
- Question 1: “The picture illustrates different radiographic stages of caries progression (approximal lesion, grade 1 to 6). Starting at which lesion size do you think an immediate restorative treatment is required? If lesion size is small, select the Figure number with the smallest lesion size for which you would not postpone restorative treatment under any circumstances even if the patient has low caries activity and good oral hygiene.”
- Question 2: “Which type of preparation would you prefer for the smallest approximal lesion you decided to drill and fill? (Imagine that the approximal lesion is situated distally on the second premolar in the upper jaw.)”
- Question 3: “Which restorative material would you choose for the smallest approximal lesion you would restore?”

OCCLUSAL LESION (FIGURE 2)‡
- Question 1: “The picture illustrates different clinical appearances of occlusal caries in a lower second molar (grade 1 to 5). Starting at which lesion do you think immediate restorative (operative) treatment is required? Please, pick the smallest lesion size you think requires immediate restorative treatment. In other words, the lesion for which you would not postpone restorative treatment under any circumstances. The patient is 20 years old, has low caries activity and good oral hygiene.”
- Question 2: “Which type of preparation would you prefer for the smallest of the lesions you decided to drill and fill?”
- Question 3: “Which restorative material would you choose for the smallest approximal lesion you would restore?”

CLINICAL CASE 1 (FIGURE 3)‡
- Question 1: “Do you think that, from its clinical and radiographic appearance, the tooth has occlusal (enamel or dentin) caries?”
- Question 2: “How would you treat this occlusal surface? You have not seen the patient before, and 2 years have elapsed since his last dental examination. The patient uses fluoride toothpaste on a daily basis and dietary and oral hygiene habits are considered satisfactory.”

CLINICAL CASE 2 (FIGURE 4)†
- Question 1: “Do you think that, from its clinical and radiographic appearance, the tooth has occlusal (enamel or dentin) caries?”
- Question 2: “How would you treat this occlusal surface? You have not seen the patient before, and 2 years have elapsed since his last dental examination. The patient uses fluoride toothpaste on a daily basis and dietary and oral hygiene habits are considered satisfactory.”

* Adapted with permission of the publisher from Espelid and colleagues and Tveit and colleagues.

We performed descriptive analyses to characterize the respondent population and the responses to the different questions related to the management strategies for approximal and occlusal carious lesions. We used a χ2 test to assess the relationship between the management strategies and some demographic characteristics (sex, years since graduation, and the respondents’ type of practice). We used subgroups for further analyses. The first set of subgroups was years since graduation (20 years or less versus more than 20 years ago). For the second set of subgroups, we merged grades for both approximal and occlusal thresholds with regard to clinical relevance. Merging occurred with regard to potential treatment options and likelihood of successful lesion remineralization. The approximal carious lesion

ABBREVIATION KEY. CA: California. DEJ: Dentinoenamel junction. GP: General practitioner.
Restorative threshold subgroup was carious lesions grades 1 and 2 (merged) versus lesions grade 3 versus lesions grade 4 versus lesions grades 5 and 6 (merged). The occlusal restorative threshold subgroup was carious lesion grades 1 and 2 (merged) versus lesions grade 3 versus lesions grades 4 and 5 (merged).

We performed the statistical analyses by using SPSS 19 (IBM). We set the level of significance at 5%.

RESULTS

Respondents. A total of 1,922 dentists (11.3%) replied to the Web-based questionnaire survey. Of these, we excluded 80 respondents because they only answered questions related to their demographic characteristics. Of the remaining 1,842 respondents, 87.5% were GPs, and 12.5% were specialists that included 5.9% pediatric dentists. Most of the remaining specialists were prosthodontists and orthodontists plus a few others who appeared to feel competent to answer caries-related questions. Table 1 summarizes the demographic characteristics of the CA dentists contacted and the respondents. Sex distribution and average age were similar for both groups; 9% more GPs and 9% fewer specialists were among the respondents. In addition, 50% more pediatric dentists participated than were accounted for in the group of contacted dentists.

Restorative management of approximal carious lesions. Eighteen percent of the respondents suggested restorative treatment and would not delay treatment under any circumstances for a lesion confined to enamel (grades 1 and 2), 42.6% would not delay treatment for a lesion at the dentinocemental junction (DEJ) (grade 3), and 33.4% would restore when the lesion reached the outer one-third of dentin (grade 4) (Figure 1). The preferred preparation type (54.1%) was the traditional Class II preparation, and 45.9% of respondents preferred a minimally invasive cavity preparation (tunnel or saucer shaped). Most of the respondents (92.6%) recommended tooth-colored material (resin-based composite, glass ionomer cement, resin-modified glass ionomer cement, and sandwich-technique glass ionomer cement), 6.4% recommended amalgam, and 1% proposed other kinds of materials (for example, gold). The preferred preparation type and the suggested restorative materials were independent from the reported treatment threshold level.

Restorative management of occlusal carious lesions. Almost 41% of the respondents would restore and would not delay treatment under any circumstances for a lesion confined to enamel (grades 1 and 2). One-half of the respondents (49.9%) would restore an occlusal lesion that involved the outer one-third of dentin (grade 3), and 9.4% considered a lesion in the middle one-third of dentin or deeper (grades 4 and 5) as the smallest lesion requiring immediate restoration placement (Figure 2).

When asked about the extension of their restorative treatment, 64.6% of the respondents would limit their cavity preparation to the carious area, 31.5% preferred a preparation including the whole occlusal fissure system, and 3.9% chose other types of preparation (for example, preparation for an inlay). Regarding the recommended restorative material, most (94.6%) chose tooth-colored materials, 4.7% chose amalgam, and 0.7% would use other types of material (for example, gold, ceramic). Again, the preferred preparation type and the suggested restorative materials were independent from the reported treatment threshold level.
Diagnosis and management of occlusal carious lesions. Clinical case 1. The most common diagnosis (92.5%) for the occlusal surface of clinical case 1 (Figure 3) was the presence of a dentin lesion, and 97.2% of respondents would restore the tooth. Table 2 presents the caries management alternatives for this lesion chosen by the respondents.

Clinical case 2. The most common diagnosis (50.5%) for the occlusal surface of clinical case 2 (Figure 4) was the presence of an enamel lesion. The respondents varied markedly in their diagnosis. Fewer dentists would restore this tooth than in clinical case 1, but more than one-half of them (56.9%) still would restore this noncavitated lesion. Table 2 presents the caries management alternatives related to this enamel lesion chosen by the respondents.

Influence of type of practice and number of years since graduation on caries management strategies. For approximal carious lesions, the $\chi^2$ test showed that respondents who graduated 20 years ago or less were more likely to suggest invasive restorative treatment for lesions at a later stage (outer one-third of dentin involved) than were those who graduated more than 20 years ago (lesion confined to enamel) ($P < .0001$) (Table 3). We also found a significant relationship between the restorative threshold for approximal lesions and the type of practice: pediatric dentists would suggest a restoration at later stages of approximal lesions than would GPs ($P < .0001$).

We found no significant relationship between sex and restorative decisions. The management decisions for occlusal carious lesions were not influenced by any of the recorded demographic characteristics.

DISCUSSION

Investigators have studied restorative treatment strategies by means of questionnaire surveys among practicing dentists in many countries (for example, Australia, Brazil, Canada, Croatia, France, Iran, Kuwait, The Netherlands, Scandinavia, Scotland, and the United States). Espelid and colleagues and Tveit and colleagues developed the questionnaire used in our study, and it is the most commonly used, thus allowing comparisons. We formatted the questionnaire for use as a Web-based survey.

The demographic characteristics of CA dentists in the original database favorably compared with those of the respondents regarding the distribution of sex and age. When taking into account that nonrestorative specialists who typically do not manage caries-related treatment decisions directly did not reply to the survey, the ratio of GPs to specialists actually answering the survey appeared representative. Because 50% more pediatric dentists answered the survey, we may conclude that pediatric dentists were slightly overrepresented in the response.

The response rate in this Web-based survey was 11.3% and thus much lower than response rates of similar mailed
surveys, which generally achieved responses between 40% and 80%. Web-based surveys have lower response rates. Rosenstiel and colleagues in 2004 surveyed 12,000 US dentists about their molar restoration choices and longevity with a response rate of 6.3%. In surveys of specialists about specifics in their field, the response rate is generally higher, between 15% and 40%.

The response rate in our study was similar to the rate of dentists in Ontario, Canada, who were asked a detailed question about treating teeth with apical periodontitis. When queried about their preference of an endodontic treatment or extraction without and with replacement by an implant, the specialists answered at a 40% response rate on a mailed survey, and the GPs showed a 15% response rate to the same Web-based survey.

Restorative threshold. Studies in which the investigators have surveyed dentists’ restorative thresholds reveal wide variations (Table 4). In some countries, most dentists would restore approximal lesions confined to enamel. In others, most dentists recommended treatment only when the lesion has reached the outer one-third and the middle one-third of dentin, respectively.

In this regard, Scandinavia appears to play a leading role. For more than 16 years, the restorative treatment threshold has been high, abstaining from restorative options until the lesion had progressed far into dentin. Results from studies in Norway also have shown that administering the same survey several years later resulted in the treatment thresholds that moved consistently toward deeper lesions.

In our study, most CA dentists reported their restorative treatment threshold for lesions that had reached the DEJ. One-third of the dentists would recommend a cavity preparation and restoration for a lesion extending into the outer one-third of dentin. In contrast to this conservative behavior, almost 20% of the respondents would recommend restorative intervention at much earlier stages with lesions confined to enamel. This practice is not consistent with the literature and potential remineralization and reversal of these lesions.

For occlusal lesions, fewer data were available for comparison (Table 5). More than 40% of CA dentists suggested an immediate restoration for an early stage of caries progression (grades 1 and 2). Almost one-half of the French dentists decided to intervene restoratively at a more advanced dentinal lesion level (outer or middle one-third of dentin), and in 2012 the threshold of French dentists also had shifted to more progressed lesions. Similarly for approximal lesions, dentists in Sweden and Kuwait reported their restorative threshold at even more advanced occlusal lesions.
As for all dentist surveys, one should keep in mind that showing a picture of an occlusal lesion and saying that radiographically the lesion is evident in the outer one-third of dentin, for example, may have elicited a more aggressive treatment response than showing the image alone, without a description. To be able to compare the results of this survey of CA dentists with results of surveys performed earlier and more recently in other countries, we decided to use an unchanged version of the survey. This survey is more than 10 years old, so survey terms such as noncavitated were yet not integrated.

Preparation type and material. When dentists decide that a restorative approach to an approximal lesion is needed, a minimally invasive removal of tooth structure should be the goal. Whereas the tunnel-shape preparation was not successful because of the obliterated view of the preparation field and recurrent carious lesions, the saucer-shape preparation preserves tooth structure.\textsuperscript{40,41} Practitioners have used the saucer-shape preparation, a minimally invasive slot preparation with extensive bevels primarily located in the enamel, successfully in long-term studies.\textsuperscript{45-43}

Most dentists in Norway and France indicated the saucer-shape preparation as their preferred treatment approach.\textsuperscript{44-44} In contrast, most of the surveyed CA and Kuwait dentists choose the traditional Class II approach.\textsuperscript{21} Conversely, despite this invasive approach for approximal lesions, most CA respondents and Kuwait dentists would remove only carious tissue for occlusal lesions.\textsuperscript{21} Notably, for the additional clinical cases included in our study (clinical cases 1 and 2), most practitioners opted for restorative interventions over the more conservative sealant and treatment with fluorides and no treatment, respectively.

Although sealants are recommended for noncavitated lesions,\textsuperscript{15} other researchers\textsuperscript{2} have demonstrated that ultraconservative sealed amalgam and resin-based composite restorations placed directly over frank cavitated lesions extending into dentin exhibited superior clinical performance and longevity. Also, enamel-bonded composite resin restorations placed over cavitated lesions arrested the clinical progress of these lesions for 10 years.\textsuperscript{2,3} The restorative material of choice in all countries was tooth-colored restorations.

Today, dentists should know that operative dental treatment alone does not ensure oral health.\textsuperscript{45} In a 2012 caries clinical trial,\textsuperscript{7} the investigators demonstrated that placing restorations in the control group did not reduce the mutans streptococci bacterial challenge significantly nor did placing restorations significantly change the caries risk status. Only targeted antibacterial and fluoride therapy based on salivary microbial and fluoride levels favorably altered the balance between pathologic and protective caries risk factors.\textsuperscript{7}

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**Figure 4.** Answers to the question "For clinical case 2, do you think that, from its clinical and radiographic appearance, the tooth has an occlusal (enamel or dentin) caries lesion?" There were 1,796 respondents.

A. Radiographic view of the tooth. B. Clinical view of the tooth. C. Practitioners’ answers to the question. Adapted with permission of the publisher from Mejare and colleagues.\textsuperscript{19}
Early restorative intervention is especially inappropriate because it starts a process known as the repeat restoration cycle or the cycle of rerestorations, each restoration being less prophylactic and more iatrogenic than the previous one, which can cause early loss of the tooth.\textsuperscript{45} Therefore, traditional restorative dentistry protocols may be outdated.

In Norway, dentists changed the clinical criteria for intervention in the caries process.\textsuperscript{47} As a result, the number of restored surfaces was reduced dramatically in the 1980s because of a change in the criteria for placement of restorations in the treatment of enamel lesions.\textsuperscript{47} The number of restored surfaces decreased by 92\% because clinicians treated carious lesions in the enamel preventively instead of restoratively.\textsuperscript{48} Those lesions were proximal. Lesions reaching into the outer one-half of dentin were treated successfully 32\% less often with a filling but rather with preventive measures.\textsuperscript{47}

Dental education and treatment criteria have evolved over time. Younger dentists may be educated about new principles such as minimal intervention dentistry, Caries Management by Risk Assessment, and minimally invasive dentistry. This difference was demonstrated in a French study in which older dentists favored opening the whole fissure when restoring occlusal carious lesions significantly more often than did younger dentists.\textsuperscript{20}

In our study, CA dentists with 20 or fewer years since graduation decided to restore proximal lesions invasively at a signifi cantly later stage in caries progression than did those who graduated more than 20 years ago. Although in The Dental Practice-Based Research Network survey female dentists suggested a restorative treatment of proximal carious lesions at a further progressed stage than did male respondents,\textsuperscript{51} in our study we did not find those sex differences. Results from our study showed that pediatric dentists suggested restorative treatment for proximal carious lesions at significantly later stages than did GPs.

These groups have accepted that demineralized but noncavitated enamel and dentin can be remineralized; therefore, the traditional operative approach of “drilling and filling” no longer may be necessary and appropriate for such lesions. Noncavitated lesions have lost mineral at different degrees, but there is no physical loss of enamel prisms, nor is there localized enamel breakdown.\textsuperscript{50} The philosophy of minimal intervention dictates that operative intervention should be performed only when cavitation is present.\textsuperscript{51} Some enamel lesions never penetrate into dentin, and up to 60\% of lesions in the outer one-half of dentin are noncavitated and can be arrested.\textsuperscript{52,53} Therefore, postponement of restorative intervention should be taken into consideration accordingly.\textsuperscript{54,55}

### TABLE 2

<table>
<thead>
<tr>
<th>MANAGEMENT STRATEGY</th>
<th>CLINICAL CASE 1, NO. (%)</th>
<th>CLINICAL CASE 2, NO. (%)</th>
</tr>
</thead>
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<tr>
<td>No Treatment</td>
<td>13 (0.7)</td>
<td>220 (12.4)</td>
</tr>
<tr>
<td>Fluoride Treatment</td>
<td>8 (0.4)</td>
<td>101 (5.7)</td>
</tr>
<tr>
<td>Sealant</td>
<td>30 (1.7)</td>
<td>443 (25.0)</td>
</tr>
<tr>
<td>Prepare Carious Part and Restore</td>
<td>351 (19.5)</td>
<td>219 (12.3)</td>
</tr>
<tr>
<td>Prepare Carious Part, Restore, and Seal Whole Fissure</td>
<td>962 (53.4)</td>
<td>539 (30.4)</td>
</tr>
<tr>
<td>Prepare Whole Fissure and Restore</td>
<td>438 (24.3)</td>
<td>252 (14.2)</td>
</tr>
</tbody>
</table>

* Not all participants responded to all questions; treatment decisions presented are independent of suggested diagnosis.

### TABLE 3

<table>
<thead>
<tr>
<th>RESTORATIVE THRESHOLD</th>
<th>TYPE OF PRACTICE, % (NO.)</th>
<th>P VALUE</th>
<th>YEARS SINCE GRADUATION, % (NO.)*</th>
<th>P VALUE</th>
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<td></td>
<td>GP\textsuperscript{1}</td>
<td>Pediatric Dentists</td>
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<td></td>
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<td>Approximal Lesion\textsuperscript{2}</td>
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<tr>
<td>Grades 1 and 2</td>
<td>18.3 (291)</td>
<td>9.3 (10)</td>
<td>&lt; .0001</td>
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<tr>
<td>Grade 3</td>
<td>43.6 (694)</td>
<td>30.6 (33)</td>
<td>40.3 (426)</td>
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<tr>
<td>Grade 4</td>
<td>32.3 (515)</td>
<td>49.1 (53)</td>
<td>32.3 (341)</td>
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<tr>
<td>Grades 5 and 6</td>
<td>5.8 (92)</td>
<td>11.1 (12)</td>
<td>7.3 (77)</td>
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<tr>
<td>Occlusal Lesion\textsuperscript{3}</td>
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<td></td>
<td>.05</td>
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<tr>
<td>Grades 1 and 2</td>
<td>41.7 (660)</td>
<td>35.2 (37)</td>
<td>39.3 (409)</td>
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<tr>
<td>Grade 3</td>
<td>49.2 (778)</td>
<td>57.1 (60)</td>
<td>50.0 (521)</td>
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<tr>
<td>Grades 4 and 5</td>
<td>9.1 (144)</td>
<td>7.6 (8)</td>
<td>10.7 (112)</td>
<td></td>
</tr>
</tbody>
</table>

* At the time of the survey (2013).
\textsuperscript{1} GP: General practitioner.
\textsuperscript{2} Cross-tabulations related to proximal lesions: Restorative threshold per type of practice: 1,700 respondents.
\textsuperscript{3} Cross-tabulations related to occlusal lesions: Restorative threshold per years since graduation: 1,808 respondents.

Original Contributions

The number of restored surfaces decreased by 92\% because clinicians treated carious lesions in the enamel preventively instead of restoratively.\textsuperscript{48} Those lesions were proximal. Lesions reaching into the outer one-half of dentin were treated successfully 32\% less often with a filling but rather with preventive measures.\textsuperscript{47}

Dental education and treatment criteria have evolved over time. Younger dentists may be educated about new principles such as minimal intervention dentistry, Caries Management by Risk Assessment, and minimally invasive dentistry. This difference was demonstrated in a French study in which older dentists favored opening the whole fissure when restoring occlusal carious lesions significantly more often than did younger dentists.\textsuperscript{20}

In our study, CA dentists with 20 or fewer years since graduation decided to restore proximal lesions invasively at a significantly later stage in caries progression than did those who graduated more than 20 years ago. Although in The Dental Practice-Based Research Network survey female dentists suggested a restorative treatment of proximal carious lesions at a further progressed stage than did male respondents,\textsuperscript{51} in our study we did not find those sex differences. Results from our study showed that pediatric dentists suggested restorative treatment for proximal carious lesions at significantly later stages than did GPs.
In a qualitative study of private practice dentists to assess barriers to the use of evidence-based clinical recommendations in the treatment of noncavitated occlusal carious lesions, the investigators realized that diagnosis of and knowledge about noncavitated lesions were limited; despite the presented fact that the lesion was noncavitated, 50% would base their treatment decision on the presence or absence of the sticking of a sharp explorer.

Future education of dentists should emphasize that noncavitated lesions can be remineralized easily but that the surface of any noncavitated lesion can be changed into a cavitated lesion by the stick of an explorer.

For approximal lesions, in which the visibility of a cavitation is limited, slight tooth separation by using a wedge could be a last resort for clarification, resulting in most correct clinical management decisions and most correct decisions regarding the choice of treatment as shown by a study. Direct application of fluoride to the lesion or resin infiltration can be regarded as treatment choices.

Results from some studies have shown that the treatment prescription strongly depends on which caries risk scenario is given. When the risk is presented as high, more dentists recommend invasive treatment than when the risk is described as low for the same lesion depth confined to enamel. The appropriate treatment suggestion still would have been a remineralization technique and other caries management measures. In our survey, the caries risk was suggested as relatively low. Finally, determination of lesion activity by using, for instance, the observational clinical criteria in Nyvad and colleagues’ article also may influence the caries management decision. As a shortcoming of this survey, in which participants were shown one photograph or radiograph to make a decision, no prior lesion status was presented.

CONCLUSIONS
There is a wide disparity between CA dentists regarding their restorative treatment decisions. Most CA dentists reported their restorative treatment threshold was for lesions that had reached the DEJ. Only one-third of the dentists would recommend a cavity preparation and restoration for a lesion extending into the outer one-third of dentin. In contrast, dentists in Scandinavia

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**TABLE 4**

**Restorative threshold for approximal lesions reported in various countries, with number of surveys sent out and percentage of respondents, lesion depth, preferred type of preparation, and preferred restorative material.**

<table>
<thead>
<tr>
<th>AUTHOR, YEAR (COUNTRY)</th>
<th>SURVEY POPULATION</th>
<th>LESION DEPTH, %*</th>
<th>DEJ†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Surveys</td>
<td>Response Rate, %</td>
<td>Outer One-Half Enamel</td>
</tr>
<tr>
<td>Riordan and Colleagues, 1991 (Australia)</td>
<td>45</td>
<td>95.1</td>
<td>2</td>
</tr>
<tr>
<td>el-Mowafy and Lewis, 1994 (Canada)</td>
<td>2,450</td>
<td>52.1</td>
<td>1</td>
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<tr>
<td>Mejare and Colleagues, 1999 (Sweden)</td>
<td>923</td>
<td>70.5</td>
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<tr>
<td>Tveit and Colleagues, 1999 (Norway)</td>
<td>640</td>
<td>84.4</td>
<td>4**</td>
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<tr>
<td>Doméjean-Oriagu et Colleagues, 2004 (France)</td>
<td>2,000</td>
<td>39.1</td>
<td>20</td>
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<tr>
<td>Traebert and Colleagues, 2005 (Brazil)</td>
<td>840</td>
<td>89.4</td>
<td>32</td>
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<tr>
<td>Ghasemi and Colleagues, 2008 (Iran)</td>
<td>1,033</td>
<td>1†</td>
<td>8</td>
</tr>
<tr>
<td>Baraba and Colleagues, 2010 (Croatia)</td>
<td>800</td>
<td>38.0</td>
<td>10</td>
</tr>
<tr>
<td>Vidnes-Kopperud and Colleagues, 2011 (Norway)</td>
<td>3,654</td>
<td>61.0</td>
<td>1**</td>
</tr>
<tr>
<td>Heaven and Colleagues, 2013 (United States)</td>
<td>901</td>
<td>63.0</td>
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</tr>
<tr>
<td>Khalaf and Colleagues, 2014 (Kuwait)</td>
<td>200</td>
<td>92.5</td>
<td>2</td>
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<tr>
<td>Present Study (United States)</td>
<td>16,960</td>
<td>11.3</td>
<td>3</td>
</tr>
</tbody>
</table>

* Percentages are rounded for lesion depth, so they do not necessarily total 100.
† DEJ: Dentinoenamel junction.
‡ Not available.
§ Just beyond DEJ.
‖ Includes outer one-half of dentin.
# Two different surveyed areas.
** These studies only reported for the combined class and lesion depth.
†† Dentists at 2 conferences.
‡‡Outer one-half of dentin.
§§ Inner one-half of dentin.
††† The picture did not show the DEJ obviously.
TABLE 4 (CONTINUED)

<table>
<thead>
<tr>
<th>Lesion Depth, %*</th>
<th>Preparation Type, %</th>
<th>Restorative Material, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer One-Third Dentin</td>
<td>Middle One-Third Dentin</td>
<td>Inner One-Third Dentin</td>
</tr>
<tr>
<td>40</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>5†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>52</td>
<td>1</td>
</tr>
<tr>
<td>62</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>–</td>
</tr>
<tr>
<td>58††</td>
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</tr>
<tr>
<td>18</td>
<td>1††</td>
<td>0††</td>
</tr>
<tr>
<td>57</td>
<td>36</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td></td>
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<tr>
<td>40</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>33</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

* Percentages are rounded for lesion depth.
† Not available.
are much more reluctant to provide invasive restorative treatment and prefer treatment at more pronounced stages. The same is true for restorative treatment decisions for occlusal lesions, for which CA dentists decided to intervene restoratively at a dentinal lesion level at the outer or middle one-third of dentin.

Because clinical evidence shows that carious lesions can be remineralized, early restorative treatment no longer seems to be necessary or appropriate. Noninvasive or minimally invasive measures should be taken into consideration when judging the need for invasive restorative treatment. In this study, we found that recent dental graduates and pediatric dentists were more likely to place their restorative threshold at deeper lesions for approximal caries. These CA dentists seem to have embraced a minimally invasive and, even more important, the remineralization concept.

However, dentists still need to be trained in distinguishing between cavitated and noncavitated lesions and when it is appropriate to use remineralization therapy rather than invasive restorative methods.

Financial incentives for remineralization of noncavitated lesions and more minimal invasive treatment would be appropriate to change behavior.

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