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Conservative cavity preparations

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Our ability to prevent the occurrence of dental caries and to restore cariously involved teeth through remineralization should relegate tooth restorations involving the cutting of teeth to the last position in the quest to preserve a healthy dentition. When the cutting of a tooth to remove carious lesions is necessary, there is growing evidence that, for long-term preservation of the tooth-restoration unit, tooth preparations should be just large enough to allow the removal of carious dentin, and that the long-honored precept of "extension for prevention" should be accomplished in a tooth-conserving way or not at all.

The profession appropriately reveres Greene Vardiman Black; he has been called the father of scientific dentistry. Dr. Black was an innovative and insightful teacher, researcher, and clinician who undoubtedly did more to bring about quality in restorative dentistry than any of his contemporaries or any of those who followed him. We should continue to honor the memory of Dr. Black and his tremendous accomplishments, but we should also view his contributions within the context of their time period. Dr. Black began to teach dentistry in 1870. He taught, conducted research, and published more than 500 articles and several textbooks within the 45-year period between 1870 and his death in 1915. He is quoted as saying to students in 1896, "The day is surely coming, and perhaps within the lifetime of you young men before me, when we will be engaged in practicing preventive, rather than reparative, dentistry." [1] Although his prophecy did not come to pass as soon as he believed, we have the science and technology today to enable us to practice true preventive dentistry.

Black's works in the area of operative dentistry were amazingly insightful and scientific for the time. But the profession has clung too much to Black's work, accomplished in the 1800s and early 1900s, and to the teachings of those who wrote succeeding editions of his textbook, *Operative Dentistry*. If Black

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were alive today, with the advances in technologies and therapies, he would be leading us in their development and incorporation into our practices.

Dr. Miles Markley, who died in 2000, deserves much of the credit for bringing to the profession concepts of minimal intervention. From the 1930s until his retirement from practice in the 1970s, Dr. Markley used many of the preventive strategies available to us today. He also provided his patients with small restorations when the carious lesions were small. He worked to convince other practicing dentists and dental school faculties of the benefits to patients of this philosophy of minimal intervention. Dr. Markley used all of the proven restorative materials of the time for his patients, but he used them in ways that were conservative of sound tooth structure. This method was not the prevailing philosophy in dental practices of that day and was not the philosophy being taught in dental schools.

Nonsurgical treatment of caries

Because terms are used differently in the profession and in different parts of the country, some words used in this article should be defined. The term *groove*, as used herein, refers to the valley or channel that separates lobes or cusps of a posterior tooth. A *fissure* is a developmental cleft or defect in the enamel; it may extend only within enamel, or it may extend to dentin. At the base of a groove may be confluent, unfissured enamel, or there may be a fissure.

The detection of a carious lesion is only one aspect in the diagnosis of caries. A more important factor is the determination of caries activity. Caries activity is defined as occurring when attached dental plaque is causing demineralization in underlying tooth structure. [2] In both white spot lesions and areas of cavitation, tooth structure may be undergoing demineralization, or the lesion may be static or arrested. For a lesion involving only enamel or enamel and a slight amount of dentin, the lesion may be remineralized. Caries activity may be determined only by observation of a lesion over time, usually by comparison of radiographs or other recorded information about the status of the lesion. [2] The nonsurgical treatment of caries is extremely important, but it is not the topic of this article. It must be emphasized, however, that a preventive regimen should be used whenever caries activity is determined to be present. Surgical or invasive intervention should be avoided if possible, but when it is necessary, it should be as tooth conserving as possible, and a regimen to prevent future caries activity should be incorporated into the treatment.

Magnification

Although conservative tooth preparations may involve the replacement of cusps with a restorative material if it is necessary to prevent tooth fracture, many tooth-conserving restorations are small, as determined by the size of the situation being treated. To determine the extent of caries effect in a tooth and to limit tooth preparations to that necessitated by the lesion, magnification is beneficial and should be used.

Assessment and management of fissured tooth surfaces

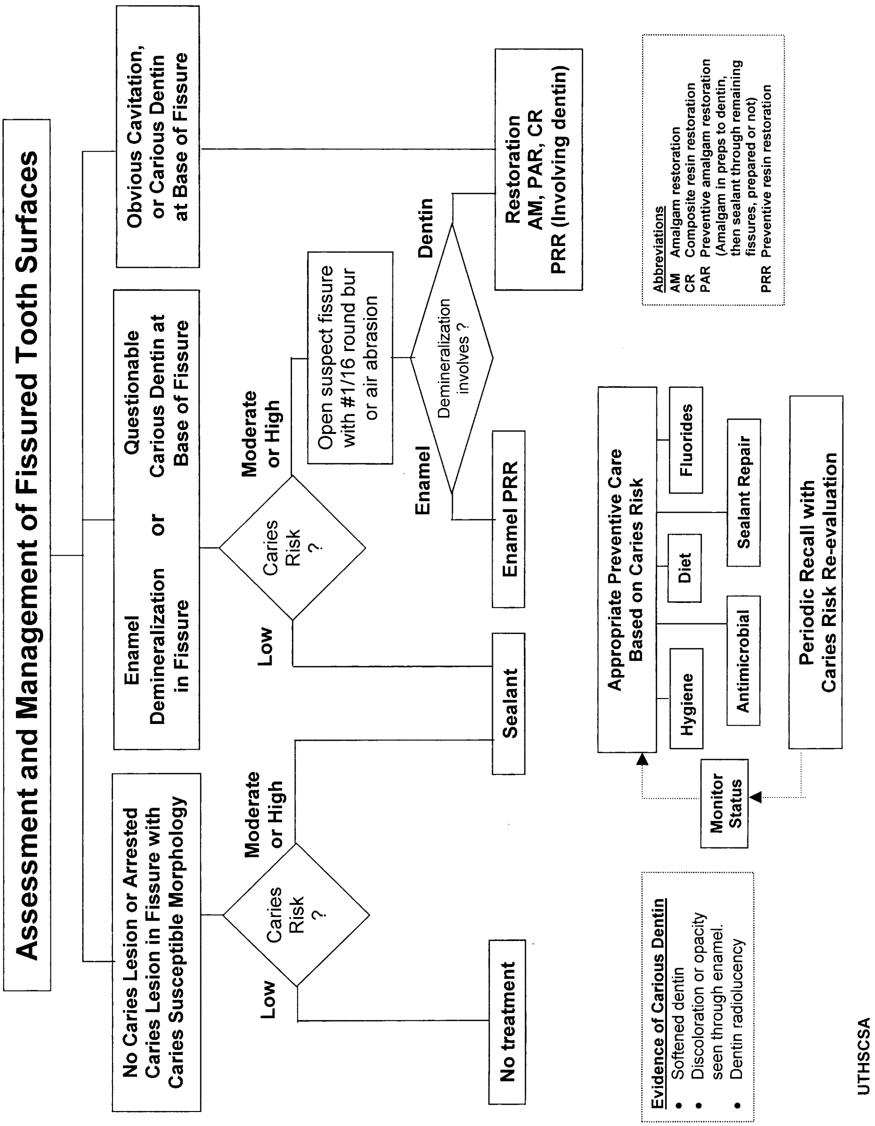
Management of fissures that are carious or subject to attack by caries in a patient at moderate or high risk for developing carious lesions has been a controversial subject. A decision tree (Fig. 1) was developed by the faculty of several departments at the University of Texas Health Science Center and was based on available evidence concerning management of fissured tooth surfaces. The caries risk status of the patient is as important as the findings of the clinical examination in determining the most appropriate treatment. Fissure sealants, as an effective way to prevent fissure caries, are supported by many controlled clinical studies and should be used as a preventive measure in patients with moderate or high caries risk.

Restoration

If the restoration to be performed is due to a carious lesion, unless it is a frank carious lesion, nonsurgical treatment should be used. One type of frank caries is displayed as cavitation, or the loss of tooth structure to form a cavity in the surface of the tooth. A cavity caused by dental caries is almost always associated with carious dentin at its base. Another type of frank carious lesion is carious dentin, detected radiographically inside the enamel layer or as softness in a root surface. Frank carious lesions, with the possible exception of shallow cavitations in free (facial or lingual) smooth surfaces, should be treated by removal of the carious tooth structure and placement of a restoration.

When surgical treatment is indicated, restorations should be conservative of tooth structure, preserving sound tooth structure and protecting or removing damaged tooth structure or tooth structure that has been weakened to the point at which it would not withstand function. In the design of cavity preparations for direct restorations, carious dentin and overlying, unsupported enamel, which is subject to fracture in function, should be removed, and a restorative material should be placed and shaped to duplicate the missing tooth structure. Extension of the preparation to dentin, through fissures that are not known to be carious, should not be accomplished.

When a fissure caries lesion is radiographically evident, the demineralization has involved dentin, and the lesion is likely more extensive than it appears to be in the radiograph. In 1998, Mertz-Fairhurst et al. [3] published the results of a significant 10-year study on restorative treatment of fissure caries. Mertz-Fairhurst and coworkers had treated radiographically evident fissure caries lesions—all involving radiographically evident carious dentin at the base of the enamel fissure—three different ways. In one group, the *traditional amalgam restoration group,* the preparations involved areas of carious dentin and extended through noncarious fissures as well. In that group, bases were placed in the deeper areas. In a second group, which the authors called the *sealed caries group*, they beveled the walls of the carious fissures to provide surfaces of nondemineralized enamel, left the carious


Assessment and Management of Fissured Tooth Surfaces
No Caries Lesion or Arrested Caries Lesion in Fissure with Caries Susceptible Morphology
Enamel Demineralization in Fissure
or
Questionable Carious Dentin at Base of Fissure
Obvious Cavitation, or Carious Dentin at Base of Fissure
Caries Risk ?
Low
Moderate or High
No treatment
Sealant
Caries Risk ?
Low
Moderate or High
Open suspect fissure with #1/16 round bur or air abrasion
Demineralization involves ?
Enamel
Dentin
Enamel PRR
Restoration AM, PAR, CR PRR (Involving dentin)
Appropriate Preventive Care Based on Caries Risk
Hygiene
Antimicrobial
Diet
Sealant Repair
Fluorides
Monitor Status
Periodic Recall with Caries Risk Re-evaluation
Evidence of Carious Dentin
• Softened dentin
• Discoloration or opacity seen through enamel.
• Dentin radiolucency
Abbreviations
AM Amalgam restoration
CR Composite resin restoration
PAR Preventive amalgam restoration (Amalgam in preps to dentin, then sealant through remaining fissures, prepared or not)
PRR Preventive resin restoration
UTHSCSA

dentin in place, etched the enamel, and placed resin composite restorations. In a third group, which the authors called the *sealed amalgam group*, they gained access to the carious dentin, removed the carious dentin and overlying unsupported enamel, and placed amalgam restorations. In that group, remaining fissures and the margins of the restorations were etched and sealed with resin. At 10 years, 17% of the traditional amalgam restorations had failed, 14% of the sealed caries restorations had failed, and 2% of the sealed amalgam restorations had failed. There was no significant difference in performance between the traditional amalgam group and the sealed caries group, but the sealed amalgam restoration group had a significantly lower failure rate than the other groups.

The results of the Mertz-Fairhurst study indicate that amalgam restorations with outline forms determined by the extent of carious dentin and overlying unsupported enamel, with remaining fissures sealed, not only perform as well as traditional amalgam restorations but also fail at a significantly lower rate. Based on this study, traditional designs for amalgam restorations should be abandoned in favor of restorations in which only carious dentin and the overlying unsupported enamel have been removed before restoration and remaining fissures have been sealed.

There is ample evidence that any undetected carious dentin or cariogenic bacteria left at the base of a fissure that has been sealed with a resin fissure sealant will not cause the continuation of the caries process. In addition to the 1998 study by Mertz-Fairhurst et al., [3] there are several other studies that support the arrestment of the caries process when the fissures are sealed. [4–7]

The mechanical instrumentation of the occlusal aspects of fissures, to obtain nondemineralized, nonstained fissure walls for better bonding, is somewhat controversial. There is, however, evidence that this procedure has benefit in improving the performance of fissure sealants. A resin sealant does not attach as well to demineralized enamel fissure walls as to clean enamel. Xie et al. [8] demonstrated that etched sound enamel provided twice the bond strength to resin as etched demineralized enamel. Kramer et al. [9] demonstrated that viable bacteria counts in fissures that had been opened with a small bur, then etched and sealed, were reduced virtually to zero. Several clinical studies have demonstrated that there is some benefit to durability of resin fissure sealants from slightly opening the fissures before sealing. [10–13] In these studies, fissures were opened with a small bur to eliminate demineralized enamel, stains, and debris in the occlusal aspect of the fissures, and to provide space for a resin sealant "plug." Air abrasion also may be used to slightly open and to "clean" the enamel walls in occlusal portions of fissures. There are a variety of types of air abrasion units, with a wide range of prices. Even after "cleaning" a fissure with air abrasion, the enamel must be etched to provide adequate attachment and seal. [14–19]

Fig. 1. Decision tree for assessment and management of fissured tooth surfaces. The specific treatment for fissures is based in large part on the individual patient's level of caries risk.

The use of dentin bonding agents or systems after etching to improve resin penetration into the fissure and enhance the seal has been demonstrated in several laboratory studies. [20–23] A clinical study [24] compared the longevity of a sealant that used a primer-dryer to a sealant that did not and found the sealants that used the primer-dryer to have significantly better retention at 2 years (96.3% complete retention with no carious fissures versus 91.4% and one carious fissure). Based on these studies and others, many investigators are recommending the use of a bonding agent for sealing all fissures.

Preparations for amalgam restorations

Because the 10-year clinical study by Mertz-Fairhurst et al. [3] demonstrated so clearly that minimal amalgam restorations used with fissure sealants perform better than traditional, extension-for-prevention, amalgam restorations, it is recommended that, for initial carious lesions, the carious dentin and overlying unsupported enamel be removed, opposing occlusally converging walls be created in some area or areas of the preparation, then amalgam be placed, and remaining caries-susceptible fissures be sealed. When remaining fissures in the tooth being restored have a morphology that makes them susceptible to the occurrence of fissure caries, they should be minimally prepared for sealing using a small bur or air abrasion to remove stains, demineralized enamel, and debris.

This procedure is relatively straightforward for occlusal amalgam restorations (Fig. 2A–C). For a carious lesion in a proximal surface, sound tooth structure (enamel and its sound dentin support) often must be removed

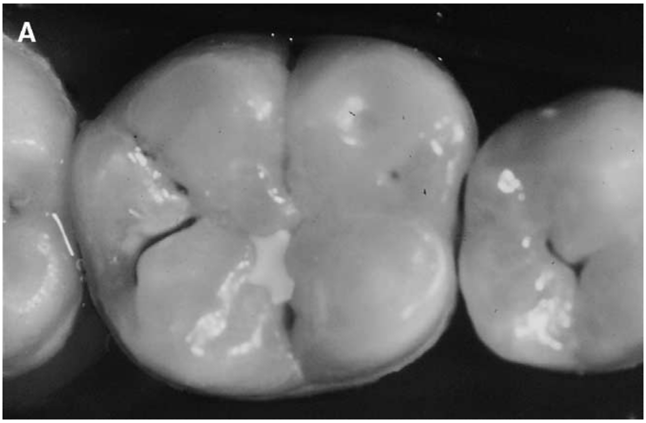


Fig. 2. Class 1 occlusal amalgam restoration, mandibular left first molar. (A) Pre-operative photograph; carious dentin has been detected only in fissure in the distal portion of the occlusal surface; (B) Preparation; the carious dentin and overlying unsupported enamel have been removed, and remaining fissures have been opened slightly with a small round bur for sealing; (C) Amalgam has been condensed and carved; and, after etching, a primer and a flowable resin composite have been applied to seal remaining fissures and margins of amalgam.

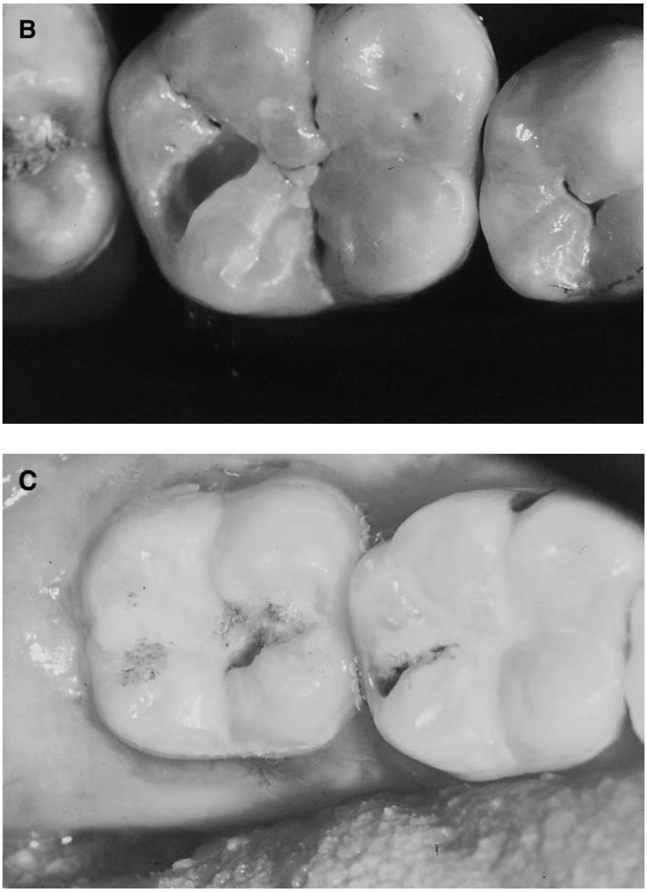


Fig. 2 (*continued*)

to gain access to the lesion. This can be accomplished by using facial or lingual access or by using occlusal access (Fig. 3A–C).

Several studies on the proximal slot amalgam restoration, with occlusal access, have been carried out. For the most part, these have been laboratory studies [25–27]; they have demonstrated that definite undercut retention for slot restorations is of utmost importance. At least one clinical study has shown complete success of slot amalgam restorations at 5 to 7 years. [28] This is the type of restoration recommended to treat initial proximal surface caries lesions. If there are separate fissure caries lesions in the same tooth, unless these lesions are immediately adjacent to the marginal ridge, they should be treated separately from the proximal slot restoration.

A slot-type restoration with facial or lingual access has been advocated by several authors [29,30] and in many cases is the most conservative type of restoration. When the carious lesion involves the interproximal contact area or

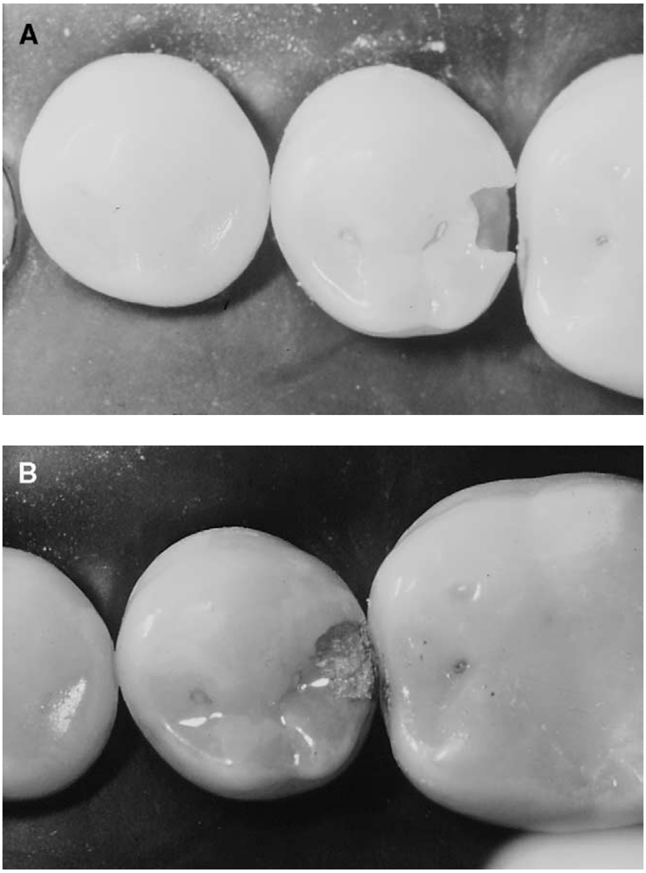


Fig. 3. Class 2 disto-occlusal slot amalgam restoration, mandibular right second premolar. (A) Preparation; (B) Amalgam has been condensed and carved and the fissure has been sealed with a clear fissure sealant; (C) Restoration after two years of service; note that resin no longer covers margins of the restoration.

when an extensive amount of sound tooth structure would have to be removed to gain access to the lesion, occlusal access is preferred, however.

The faciolingual widening of the class II preparation with occlusal access, to separate the margins of the proximal box from the adjacent tooth, has been taught in dental schools and described in textbooks for years. No study could be found to support this procedure. One clinical study [31] compared a 0.50-mm and a 0.25-mm separation and found no difference in performance after 4 years.

Preparations for resin composite restorations

As for amalgam restorations, the procedure for resin composite restorations undertaken because of initial carious lesions should include removal of

Fig. 3 (*continued*)

carious dentin and overlying unsupported enamel, placement of bonded resin composite, and protection of remaining fissures with sealant. Unlike preparations for amalgam restorations, in preparations for resin composite restorations some unsupported enamel that is not subject to occlusal loading may be left, because some enamel may be supported by bonded composite. In addition, unlike preparations for amalgam, undercut mechanical retention is not necessary because resin composite is bonded. As with amalgam restorations, the decision whether to open fissures before sealing should be based on the fissure morphology and the condition of the fissure walls.

For occlusal resin composite restorations performed because of initial carious lesions, a design similar to that for amalgam is used. That is, the carious dentin and overlying unsupported enamel are removed, resin composite is bonded, and the remaining fissures are etched and sealed (Fig. 4A–C). This *preventive resin restoration* concept was shown by Simonsen [32] to perform well over 3 years. Other clinical studies have given more evidence to the reliability of preventive resin restorations. [33–35]

For class II resin composite restorations necessitated by initial carious lesions, slot-type preparations, with access from occlusal (Fig. 5A–D), facial, or lingual aspects should be used, just as they should be used for amalgam. A difference is that no undercut retention form is necessary because of the bonding of the resin composite to the walls of the preparation. [36] Clinical evidence to support the proximal slot preparation for resin composite is somewhat scarce, but the investigators in 5-year clinical study [37] of class II resin composite restorations have stated that the slot restorations are performing well, with little evidence of wear and virtually no failures.

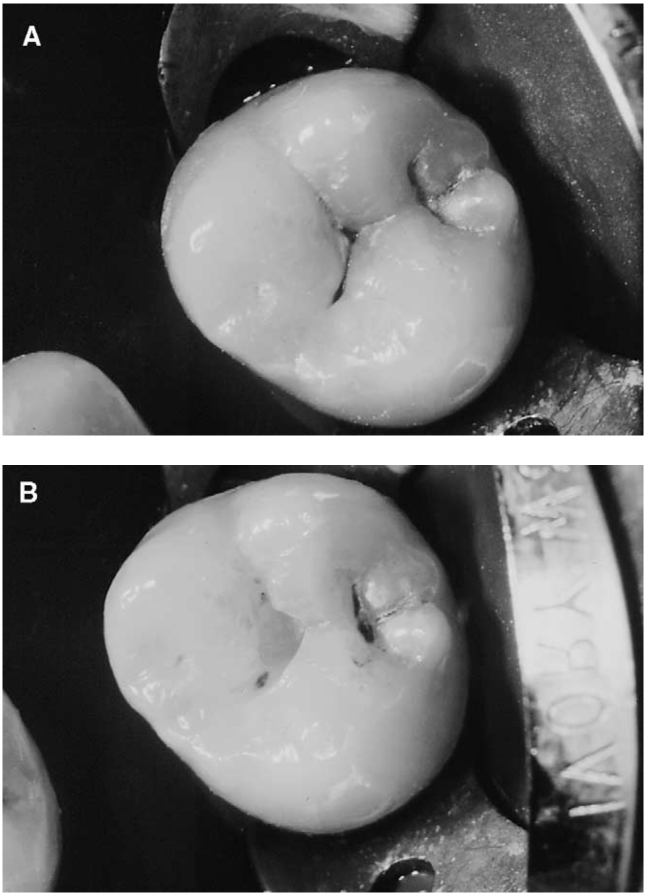


Fig. 4. Class 1 preventive resin restoration, maxillary left second molar. (A) Preoperative photograph; carious dentin has been detected only in the fissure in central fossa; (B) Preparation; the carious dentin and overlying unsupported enamel have been removed, remaining fissures opened slightly with a small round bur for sealing; (C) Completed restoration and sealed fissures.

Tunnel restorations

A glass ionomer of resin-modified glass ionomer material, instead of resin composite, is usually used for at least the proximal and internal aspects of tunnel restorations, and resin composite is used to fill the occlusal access preparation. Many practitioners attest to the clinical reliability of the tunnel restoration. Studies, however, have demonstrated that sound dentin near the pulp must be removed in performing the tunnel preparation, [38,39] and several clinical studies have shown a fairly high failure rate just a few years after placement of tunnel restorations. [28,40,41] Before this procedure is widely

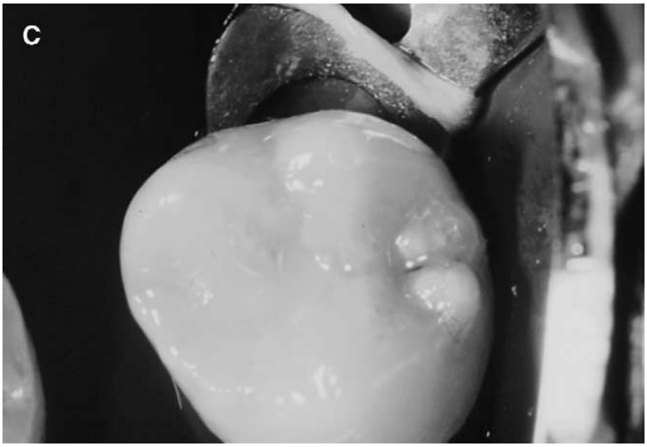


Fig. 4 (*continued*)

Fig. 5. Class 2 disto-occlusal and Mesio-occlusal slot resin composite restorations, maxillary right second premolar. (A) Preoperative photograph; (B) Slot preparations; (C) Completed restorations prior to dam removal; (D) Restorations after three years of service.

accepted, evidence is needed to support proponents' claims that it can provide a long-lasting restorative service.

Conclusion

As predicted by Dr. Black in 1896, the day has arrived when we can practice "preventive, rather than reparative dentistry." [1] It is up to practitioners and educators to work to bring about the widespread use of the techniques available to us. Carious lesions should be treated nonsurgically when possible,

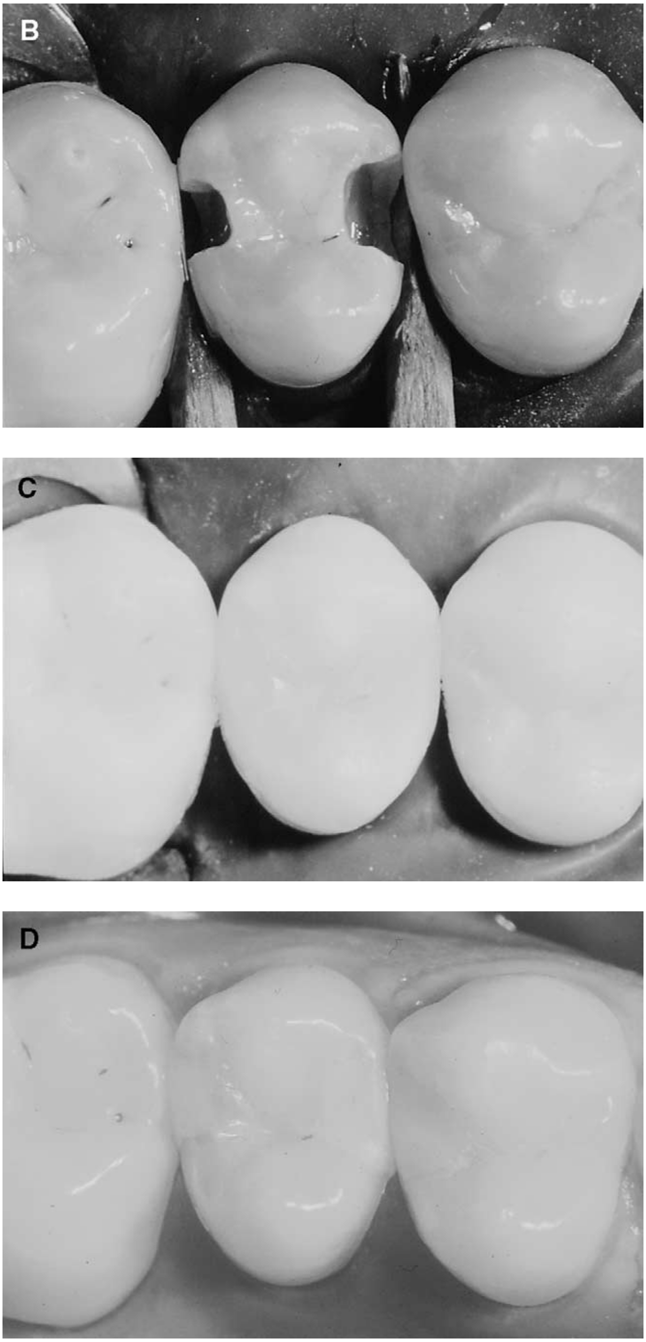


Fig. 5 (*continued*)

with patient education and with myriad fluorides, antimicrobials, and gums that encourage remineralization. Where restorative intervention is required, the most conservative "reparative" procedures should be used.

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