Sturdevant's

Art & Science of OPERATIVE DENTISTRY

A South Asian Edition

Harald O Heymann • Edward J Swift, Jr. • André V Ritter

Adaptation Editor: **V Gopikrishna**

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US Editors

Harald O Heymann, DDS, MEd
Professor, Department of Operative Dentistry
The University of North Carolina, School of Dentistry
Chapel Hill, NC

Edward J Swift, Jr, DMD, MS
Professor and Chair, Department of Operative Dentistry
The University of North Carolina, School of Dentistry
Chapel Hill, NC

André V Ritter, DDS, MS
Professor and Graduate Program Director, Department of Operative Dentistry
The University of North Carolina, School of Dentistry
Chapel Hill, NC

Adaptation Editor

V Gopikrishna, MDS, FISDR
Professor
Department of Conservative Dentistry and Endodontics
Thai Moogambigai Dental College
Dr MGR Educational and Research Institute University
Chennai, INDIA

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Brief Contents

CHAPTER

1

Clinical Significance of Dental Anatomy, Histology, Physiology and Occlusion

"Success in life is founded upon attention to the smallest of things... rather than to the largest of things..."

—Booker T Washington

A thorough understanding of the histology, physiology, and occlusal interactions of the dentition and supporting tissues is essential for the restorative dentist. Knowledge of the structures of teeth (enamel, dentin, cementum, and pulp) and their relationships to each other and to the supporting structures is necessary, especially when treating dental caries. Proper tooth form contributes to healthy supporting tissues. The relationships of form to function are especially noteworthy when considering the shape of the dental arch, proximal contacts, occlusal contacts, and mandibular movement.

Teeth and Supporting Tissues

Dentitions

Humans have *primary* and *permanent* dentitions. The primary dentition consists of 10 maxillary and 10 mandibular teeth. Primary teeth exfoliate and are replaced by the permanent dentition, which consists of 16 maxillary and 16 mandibular teeth.

Classes of Human Teeth: Form and Function

Human teeth are divided into classes on the basis of form and function. The primary and permanent dentitions include the *incisor, canine*, and *molar* classes. The fourth class, the *premolar*, is found only in the permanent dentition (Fig. 1.1). Tooth form predicts the function of teeth; class traits are the characteristics that place teeth into functional categories. Because the diet of humans consists of animal and plant foods, the human dentition is called *omnivorous*.

Incisors

The incisors are located near the entrance of the oral cavity and function as cutting or shearing instruments for food (see Fig. 1.1). From a proximal view, the crowns of these teeth have a relatively triangular

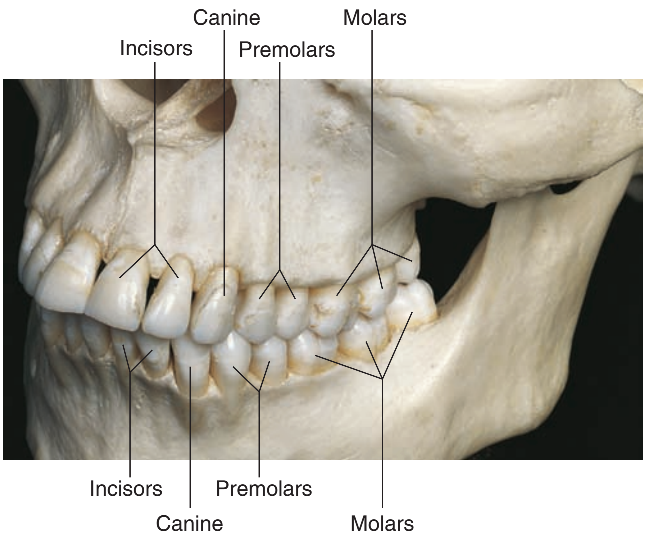


Fig. 1.1 Maxillary and mandibular teeth in maximum intercuspal position. The classes of teeth are incisors, canines, premolars, and molars. Cusps of mandibular teeth are one-half cusp anterior of corresponding cusps of teeth in the maxillary arch. *(From Logan BM, Reynolds P, Hutchings RT:* McMinn's color atlas of head and neck anatomy*, ed 4, Edinburgh, Mosby, 2010).*

shape, with a narrow incisal surface and a broad cervical base. During mastication, incisors are used to shear (cut through) food.

Clinical Notes

Incisors are essential for the proper esthetics of the smile, facial soft tissue contours (e.g. lip support), and speech (phonetics).

Canines

Canines possess the longest roots of all teeth and are located at the corners of the dental arch. They function in the seizing, piercing, tearing, and cutting of food. From a proximal view, the crown also has a triangular shape, with a thick incisal ridge. The anatomic form of the crown and the length of the root make these teeth strong, stable abutment teeth for a fixed or removable prosthesis.

Clinical Notes

Canines not only serve as important guides in occlusion because of their anchorage and position in the dental arches but also play a crucial role (along with the incisors) in the esthetics of smile and lip support (see Fig. 1.1).

Premolars

Premolars serve a dual role:

(1) They are similar to canines in the tearing of food.
(2) They are similar to molars in the grinding of food.

The occlusal surfaces of the premolars present a series of curves in the form of concavities and convexities that should be maintained throughout life for correct occlusal contacts and function.

Clinical Notes

Although less visible than incisors and canines, premolars still can play an important role in esthetics.

Molars

Molars are large, multicusped, strongly anchored teeth located nearest to the temporomandibular joint (TMJ), which serves as the fulcrum during function. These teeth have a major role in the crushing, grinding, and chewing of food to the smallest dimensions suitable for swallowing. They are well suited for this task because they have broad occlusal surfaces and multirooted anchorage (Fig. 1.2).

Clinical Notes

Premolars and molars are important in maintaining the vertical dimension of the face (see Fig. 1.1).

Structures of Teeth

Teeth are composed of enamel, the pulp–dentin complex, and cementum (see Fig. 1.2). Each of these structures is discussed individually.

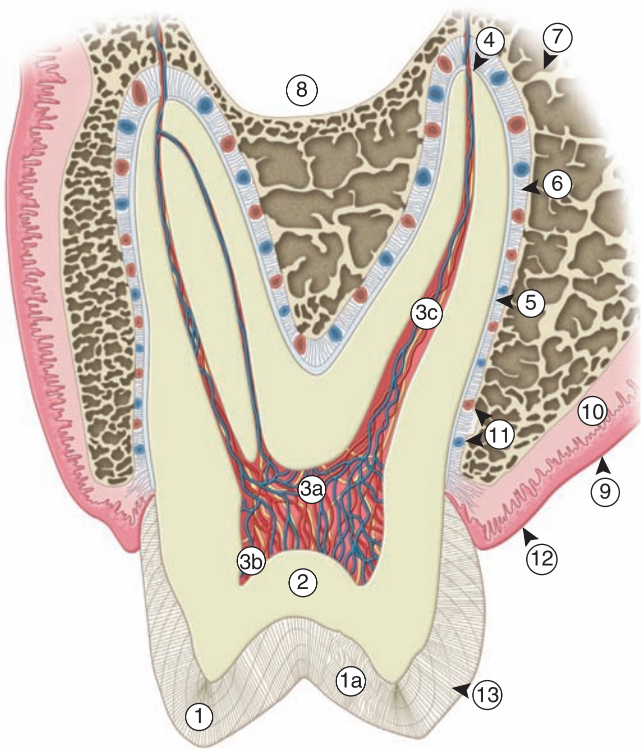


Fig. 1.2 Cross-section of the maxillary molar and its supporting structures. *1*, enamel; *1a*, gnarled enamel; *2*, dentin; *3a*, pulp chamber; *3b*, pulp horn; *3c*, pulp canal; *4*, apical foramen; *5*, cementum; *6*, periodontal fibers in periodontal ligament; *7*, alveolar bone; *8*, maxillary sinus; *9*, mucosa; *10*, submucosa; *11*, blood vessels; *12*, gingiva; *13*, striae of Retzius.

CHAPTER

2

Dental Caries: Etiology and Clinical Characteristics

"You don't know how much you know...
Until you know how much you don't know..."

This chapter presents basic definitions, terminologies and information on dental caries, and clinical characteristics of the caries lesion in the context of clinical operative dentistry.

Definition

Dental caries is defined as a multifactorial, transmissible, infectious oral disease caused primarily by the complex interaction of cariogenic oral flora (biofilm) with fermentable dietary carbohydrates on the tooth surface over time.

Demineralization – Remineralization Balance

Traditionally, the tooth-biofilm-carbohydrate interaction has been illustrated by the classical *Keyes-Jordan diagram*.[1] However, dental caries onset and activity are, in fact, much more complex than this three-way interaction, as not all persons with *teeth, biofilm*, and *consuming carbohydrates* will have caries over time. Several modifying risk and protective factors influence the dental caries process, as will be discussed later in this chapter (Fig. 2.1).

At the tooth surface and sub-surface level, dental caries results from a dynamic process of attack (demineralization) (Figs. 2.2 and 2.3) and restitution (remineralization) of the tooth matter. This cycle is summarized in Box 2.1.

The balance between demineralization and remineralization has been illustrated in terms of:

- Pathologic factors (i.e. those favoring demineralization)
- Protective factors (i.e. those favoring remineralization).[2]

Individuals in whom the balance tilts predominantly toward protective factors (remineralization) are much less likely to develop dental caries than those in whom the balance is tilted toward pathologic factors (demineralization). *Understanding the balance between demineralization and remineralization is the key to caries management.*

Clinical Notes

It is essential to understand that caries lesions, or cavitations in teeth, are signs of an underlying condition, an imbalance between protective and pathologic factors favoring the latter. In clinical practice, it is very easy to lose sight of this fact and focus entirely on the restorative treatment of caries lesions, failing to treat the underlying cause of the disease (Table 2.1). Although symptomatic treatment is important, failure to identify and treat the underlying causative factors allows the disease to continue.

Etiology of Dental Caries

Dental caries is a disease that is dependent on the complex inter-relationships between the following five critical parameters:

i Biofilm
ii Tooth habitat
iii Diet
iv Saliva
v Oral hygiene.

Table 2.6

Clinical characteristics of normal and altered enamel

	Hydrated	Desiccated	Surface texture	Surface hardness
Normal enamel	Translucent	Translucent	Smooth	Hard
Hypocalcified enamel	Opaque	Opaque	Smooth	Hard
Noncavitated caries	Translucent	Opaque	Smooth	Softened
Active caries	Opaque	Opaque	Cavitated	Very soft
Inactive caries	Opaque, dark	Opaque, dark	Roughened	Hard

Table 2.7

Clinical significance of enamel lesions

	Plaque biofilm	Enamel structure	Nonrestorative, therapeutic treatment (e.g. remineralization, antimicrobial, pH control)	Restorative treatment
Normal enamel	Normal	Normal	Not indicated	Not indicated
Hypocalcified enamel	Normal	Abnormal, but not weakened	Not indicated	Only for esthetics
Noncavitated caries	Cariogenic	Porous, weakened	Yes	Not indicated
Active caries	Cariogenic	Cavitated, very weak	Yes	Yes
Inactive caries	Normal	Remineralized, strong	Not indicated	Only for esthetics

Location These lesions usually are observed on the facial and lingual surfaces of teeth. They can also occur in the proximal surfaces but are difficult to detect.

Remineralization mechanism The remineralization mechanism of white spot lesion (WSL) is summarized in Box 2.3.

Clinical Notes

- Care must be exercised in distinguishing white spots of noncavitated caries from developmental white spot hypocalcifications of enamel.
- Noncavitated (white spot) caries partially or totally *disappears visually* when the enamel is hydrated (wet), whereas hypocalcified enamel is affected less by drying and wetting (Table 2.6).
- Hypocalcified enamel does not represent a clinical problem except for its esthetically objectionable appearance.
- Injudicious use of an explorer tip can cause actual cavitation in a previously noncavitated area, requiring, in most cases, restorative intervention.
- Noncavitated enamel lesions sometimes can be seen on radiographs as a faint radiolucency that is limited to the superficial enamel.
- When a proximal lesion is clearly visible radiographically, the lesion may have advanced significantly, and histologic alteration of the underlying dentin probably already has occurred, whether the lesion is cavitated or not (Fig. 2.26).

Box 2.3

Remineralization mechanism of a white spot lesion (WSL)

The *supersaturation* of saliva with calcium and phosphate ions serves as the driving force for the remineralization process

↓

Noncavitated enamel lesions retain most of the original crystalline framework of the enamel rods, and the etched crystallites serve as nucleating agents for remineralization

↓

Calcium and phosphate ions from saliva can penetrate the enamel surface and precipitate on the highly reactive crystalline surfaces in the enamel lesion

↓

The presence of trace amounts of *fluoride ions* during this remineralization process greatly enhances the precipitation of calcium and phosphate, resulting in the remineralized enamel becoming more resistant to subsequent caries attack because of the incorporation of more acid-resistant *fluorapatite*

↓

Remineralized (arrested) lesions can be observed clinically as intact, but discolored, usually brown or black, spots (Fig. 2.25). The change in color is presumably caused by trapped organic debris and metallic ions within the enamel. These discolored, remineralized, arrested caries areas are intact and are *more resistant* to subsequent caries attack than the adjacent unaffected enamel. They should not be restored unless they are esthetically objectionable

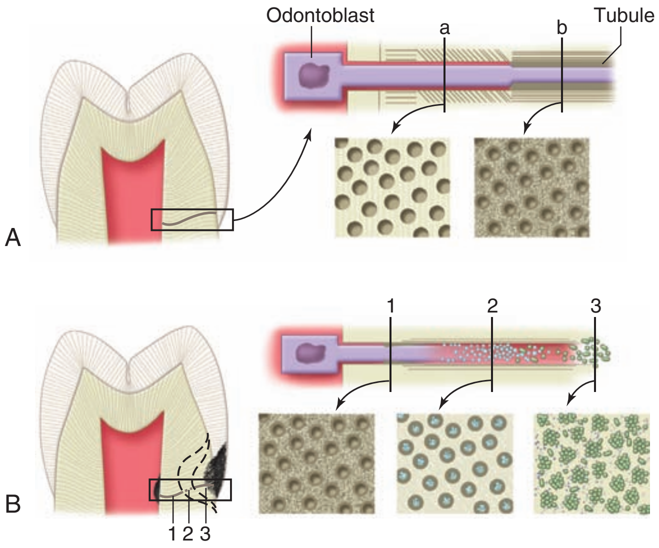


Fig. 2.28 Normal and carious dentin. **A,** As dentin grows, odontoblasts become increasingly compressed in the shrinking pulp chamber, and the number of associated tubules becomes more concentrated per unit area. The more recently formed dentin near the pulp (*a*) has large tubules with little or no peritubular dentin and calcified intertubular dentin filled with collagen fibers. Older dentin, closer to the external surface (*b*), is characterized by smaller, more widely separated tubules and a greater mineral content in intertubular dentin. Horizontal lines indicate predentin; diagonal lines indicate increasing density of minerals; darker horizontal lines indicate densely mineralized dentin and increased thickness of peritubular dentin. **B,** Carious dentin undergoes several changes. The most superficial infected zone of carious dentin (*3*) is characterized by bacteria filling the tubules and granular material in the intertubular space. As bacteria invade dentinal tubules, if carbohydrates are available, they can produce enough lactic acid to remove peritubular dentin. Pulpal to (below) the infected dentin is a zone where the dentin appears transparent in mounted whole specimens. This zone (*2*) is affected (not infected) carious dentin and is characterized by loss of mineral in the intertubular and peritubular dentin. Many crystals can be detected in the lumen of the tubules in this zone. The crystals in the tubule lumen render the refractive index of the lumen similar to that of the intertubular dentin, making the zone transparent. Normal dentin (*1*) is found pulpal to (below) transparent dentin.

Hypermineralized areas may be seen on radiographs as zones of *increased radiopacity* (often S-shaped following the course of the tubules) ahead of the advancing, infected portion of the lesion. This repair occurs only if the tooth pulp is vital.

Sclerotic dentin Dentin that has more mineral content than normal dentin is termed *sclerotic dentin*.

Sclerotic dentin formation occurs ahead of the demineralization front of a slowly advancing lesion and may be seen under an old restoration.

Sclerotic dentin is usually shiny and darker in color but feels hard to the explorer tip. By contrast, normal, freshly cut dentin lacks a shiny, reflective surface and allows some penetration from a sharp explorer tip.

The apparent function of sclerotic dentin is to wall off a lesion by blocking (sealing) the tubules.

The permeability of sclerotic dentin is greatly reduced compared with normal dentin because of the decrease in the tubule lumen diameter.[24]

2. Reaction to a moderate-intensity attack

The second level of dentinal response is to moderate-intensity irritants by forming *reparative dentin*.

Mechanism of reparative dentin formation

The mechanism of reparative dentin formation is explained in Flowchart 2.1.

Infected dentin contains a wide variety of pathogenic materials or irritants, including high acid levels, hydrolytic enzymes, bacteria, and bacterial cellular debris

↓

The pulp may be irritated sufficiently from high acid levels or bacterial enzyme production to cause the formation (from undifferentiated mesenchymal cells) of replacement odontoblasts (secondary odontoblasts)

↓

These cells produce reparative dentin (reactionary dentin) on the affected portion of the pulp chamber wall (see Figs. 2.28B)

Flowchart 2.1 Mechanism of reparative dentin formation

Clinical Notes

- This dentin is different from the normal dentinal apposition that occurs throughout the life of the tooth by primary (original) odontoblasts.
- The structure of reparative dentin varies from well-organized tubular dentin (less often) to *very irregular atubular dentin* (more often), depending on the severity of the stimulus.
- Reparative dentin is an *effective barrier* to diffusion of material through the tubules and is an important step in the repair of dentin.
- Severe stimuli also can result in the formation within the pulp chamber of unattached dentin, termed *pulp stones*, in addition to reparative dentin.
- The pulpal blood supply may be the most important limiting factor for the pulpal responses.

CHAPTER

3

Dental Caries: Risk Assessment and Management

*"There are no such things as incurables…
There are only things for which man has not yet found a cure…"*

—Bernard Baruch

Dental caries is a multifactorial medical disease process, and the caries lesions are the expression of that disease process involving the patient as a whole. It is critical to remember that clinicians treat the entire patient and not just individual teeth and caries lesions (Fig. 3.1). Equally important in the management of caries as a disease entity is the ability to individualize caries treatment or interventions for each patient. To do this, the clinician must formulate a caries risk assessment profile that is based on the patient's risk factors currently present.

Fig. 3.1 Acute, rampant caries in both anterior (*A*) and posterior (*B*) teeth.

Surgical Model of Caries Management

Historically, dentistry has used a *surgical model* for the management of dental caries, which mainly involved the biomechanical removal of caries lesions and the restoration of the resultant *tooth preparation* to form and function with a restorative material.

Management of caries disease by a surgical model consisted of waiting until cavitations were detected and treating the cavitations with restorations.

Eventually, it became apparent that dealing only with the end result of the disease and not addressing its etiology for each individual patient was not successful in controlling the caries disease process.

weeks. Chlorhexidine may be used in combination with other preventive measures in high-risk patients.

Clinical Notes

The traditional approach is the use of chlorhexidine (CHX) mouthwash, varnish, or both, along with prescription fluoride toothpaste. When using this approach, it may be prudent to use toothpaste free from sodium lauryl sulfate (SLS), which causes the foaming action in dentifrices. Although data are equivocal, evidence demonstrates that SLS reduces the ability of CHX to reduce plaque formation.[31]

2. Xylitol Xylitol is a natural five-carbon sugar obtained from birch trees. It seems to have several mechanisms of action to reduce the incidence of caries.

- Xylitol keeps the sucrose molecule from binding with MS.
- *S. mutans* cannot ferment (metabolize) xylitol, so no acid is produced.
- Xylitol reduces MS by altering the metabolic pathways.
- Finally there is some suggestion that xylitol may enhance remineralization and help arrest dentinal caries.[32,33]

Clinical Notes

- It is usually recommended that a patient chew a piece of xylitol gum for 5–30 minutes after eating or snacking.
- Chewing any sugar-free gum after meals reduces the acidogenicity of plaque because chewing stimulates salivary flow, which improves the buffering of the pH drop that occurs after eating.[34]
- Reductions in caries rates are greater, however, when xylitol is used as the sugar substitute.[35,36]
- Its efficacy is *dose related*, so care must be taken to recommend products with adequate dose levels. Current protocols suggest chewing *two pieces of gum containing a total of 1 gram of xylitol three to six times per day*, preferably after meals and snacks.

VIII. Calcium and Phosphate Compounds

A relatively new group of products, called *amorphous calcium-phosphates* (ACP) in conjunction with *casein phosphopeptide* (CPP), have become commercially available and have the potential to remineralize tooth structure.[37] The mechanism of action of the ACP-CPP compounds is shown in Box 3.1.

Box 3.1

Mechanism of remineralization action of ACP-CPP compound

Casein phosphopeptide (CPP) is a milk-derived protein that binds to the tooth's biofilm and is used to stabilize ACP

↓

ACP is a reactive and soluble calcium phosphate compound that releases calcium and phosphate ions to convert to apatite and remineralize the enamel when it comes in contact with saliva[38]

↓

Remineralization products use CPP as a vehicle and maintains a supersaturation state of ACP at or near the tooth surface

Clinical Notes

- Gum, lozenges, and topically applied solutions containing CPP-ACP have been reported to remineralize white spots.[39,40]
- Some of these products contain other caries-preventive agents such as fluoride (e.g. GC Tooth Mousse Plus, GC Asia).

Mounting evidence indicates that CPP-ACP complexes (Fig. 3.6), when used regularly, are effective in enamel remineralization.[41–44] The evidence base for ACP is not as strong as that for xylitol, but extensive clinical trials are ongoing, and the evidence that is available is supportive.

IX. Probiotics

The fundamental concept of probiotics is to inoculate the oral cavity with bacteria that will compete with cariogenic bacteria and eventually replace them.

Fig. 3.6 CPP-ACP remineralizing compound (GC Tooth Mousse, GC Asia).

CHAPTER

4

Patient Assessment, Examination, Diagnosis and Treatment Planning

"In your thirst for knowledge…
be sure not to drown in all the information…"

—Anthony J D' Angelo

This chapter provides an overview of the process through which a clinician completes patient assessment, clinical examination, diagnosis, and treatment plan for operative dentistry procedures.

Any discussion of diagnosis and treatment must begin with an appreciation of the role of the dentist in helping patients maintain their oral health. This role is summarized by the Latin phrase *primum non nocere,* which means '***do no harm***'. This phrase represents a fundamental principle of *the healing arts over many centuries.*

The success of operative treatment depends heavily on an appropriate plan of care, which, in turn, is based on a comprehensive analysis of the patient's reasons for seeking care and on a systematic assessment of the patient's current conditions and risk for future problems. This information is then combined with the best available evidence on the approaches to manage the patient's needs so that an appropriate plan of care can be offered to the patient.

The collection of this information and the determinations based on these findings should be comprehensive and occur in a stepwise manner. These steps are shown in Table 4.1.

Table 4.1

Steps in patient assessment and management

Reasons for seeking care
Medical and dental histories
Clinical examination for the detection of abnormalities
Establishing diagnosis
Assessing risk
Determining prognosis
Treatment plan

Evidence-based Dentistry

Definition Evidence-based dentistry is defined as the "conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients".[1]

Research that provides information on treatments that work best in certain situations is expanding the knowledge base of dentistry and has led to an interest in translating the results of that research into practice activities and enhanced care for patients.

Systematic reviews emerging from the focus on evidence-based dentistry will provide practitioners with a distillation of the available knowledge about various conditions and treatments.

As evidence-based dentistry continues to expand, professional associations will become more active in the development of guidelines to assist dentists and their patients in making informed and appropriate decisions.

Patient Assessment

General Considerations

Clinical examination is the 'hands-on' process of observing the patient's oral structures and detecting signs and symptoms of abnormal conditions or disease.

Fig. 4.4G Non-hereditary hypocalcified areas on facial surfaces. These areas may result from numerous factors but do not warrant restorative intervention unless they are esthetically offensive or cavitation is present.

Role of Explorer Caries lesions can be detected by visual changes in tooth surface texture or color or in tactile sensation when an explorer is used judiciously to detect surface roughness by gently stroking across the tooth surface. The recommended instrument for probing is the *Community Periodontal Index of Treatment Needs (CPITN) probe* having a 0.5mm sphere at the tip (Fig. 4.6).

Clinical Notes

- It cannot be overemphasized that the *explorer must not be used to determine a 'stick',* or a resistance to withdrawal from a fissure or pit.
- This improper use of a sharp explorer has been shown to *irreversibly damage the tooth* by turning a sound, remineralizable subsurface lesion into a possible cavitation that is prone to progression.[5-8] The use of the dental explorer for this purpose was found to fracture enamel and serve as a source for transferring pathogenic bacteria among various teeth.[9,10] Therefore, the use of a sharp explorer in diagnosing pit-and-fissure caries is *contraindicated* as part of the detection process.

2. Radiographic examination Proximal surface caries is usually diagnosed radiographically[13] (Fig. 4.7A). When caries has invaded proximal surface enamel

Occlusal Protocol ***

ICDAS code	0	1	2	3	4	5	6
							
Definitions	Sound tooth surface; no caries change after air drying (5 sec); or hypoplasia, wear, erosion, and other noncaries phenomena	First visual change in enamel; seen only after air drying or colored, change "thin" limited to the confines of the pit and fissure area	Distinct visual change in enamel; seen when wet, white or colored, "wider" than the fissure/fossa	Localized enamel breakdown with no visible dentin or underlying shadow; discontinuity of surface enamel, widening of fissure	Underlying dark shadow from dentin, with or without localized enamel breakdown	Distinct cavity with visible dentin; frank cavitation involving less than half of a tooth surface	Extensive distinct cavity with dentin; cavity is deep and wide involving more than half of the tooth
Histologic depth		Lesion depth in P/F was 90% in the outer enamel with only 10% into dentin	Lesion depth in P/F was 50% inner enamel and 50% into the outer 1/3 dentin	Lesion depth in P/F with 77% in dentin	Lesion depth in P/F with 88% into dentin	Lesion depth in P/F with 100% in dentin	Lesion depth in P/F 100% reaching inner 1/3 dentin
Sealant/restoration Recommendation for low risk	Sealant optional DIAGNOdent may be helpful	Sealant optional DIAGNOdent may be helpful	Sealant optional or caries biopsy if DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
Sealant/restoration Recommendation for moderate risk	Sealant optional DIAGNOdent may be helpful	Sealant recommended DIAGNOdent may be helpful	Sealant optional or caries biopsy if DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
Sealant/restoration Recommendation for high risk *	Sealant recommended DIAGNOdent may be helpful	Sealant recommended DIAGNOdent may be helpful	Sealant optional or caries biopsy if DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
Sealant/restoration Recommendation for extreme risk **	Sealant recommended DIAGNOdent may be helpful	Sealant recommended DIAGNOdent may be helpful	Sealant optional or caries biopsy if DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration

* Patients with one (or more) cavitated lesion(s) are high-risk patients. ** Patients with one (or more) cavitated lesion(s) and xerostomia are extreme-risk patients.

*** All sealants and restorations to be done with a minimally invasive philosophy in mind. Sealants are defined as confined to enamel. Restoration is defined as in dentin. A two-surface restoration is defined as a preparation that has one part of the preparation in dentin and the preparation extends to a second surface (note: the second surface does not have to be in dentin). A sealant can be either resin-based or glass ionomer. Resin-based sealants should have the most conservatively prepared fissures for proper bonding. Glass ionomer should be considered where the enamel is immature, or where fissure preparation is not desired, or where rubber dam isolation is not possible. Patients should be given a choice in material selection.

Fig. 4.5 International caries detection and assessment system (ICDAS) chart showing visual caries detection. *(From Jenson L, Budenz AW, Featherstone JD, et al: Clinical protocols for caries management by risk assessment,* J Calif Dent Assoc *35:714, 2007).*

CHAPTER

7

Instruments and Equipment for Tooth Preparation

*"A man who works with his hands is a … **Labourer***
*A man who works with hands and his brain is a … **Craftsman***
*A man who works with his hands and his brain and his heart is an … **Artist**."*

—Louis Nizer

Hand Instruments for Cutting

Removal and shaping of tooth structure are essential aspects of restorative dentistry. Modern high-speed equipment has eliminated the need for many hand instruments for tooth preparation. Nevertheless, hand instruments remain an essential part of the armamentarium for restorative dentistry.

The early hand-operated instruments with their large, heavy handles (Fig. 7.1) and inferior (by present standards) metal alloys in the blades were cumbersome, awkward to use, and ineffective in many situations. Among his many contributions to modern dentistry, G V Black is credited with the *first acceptable nomenclature* for and *classification of hand instruments*.[1] His classification system enabled dentists and manufacturers to communicate more clearly and effectively about instrument design and function.

Modern hand instruments, when properly used, produce beneficial results for the operator and the patient. Some of these results can be satisfactorily achieved only with hand instruments and not with rotary instruments.

Terminology and Classification

Classification

The hand instruments used in the dental operatory may be categorized in Box 7.1.[1]

Design

Most hand instruments, regardless of their use, are composed of three parts – blade, shank and handle (Fig. 7.2):

1. Blade

The blade is the working end of the instrument and is connected to the handle by the shank.

For many noncutting instruments, the part corresponding to the blade is termed *nib*.

The end of the nib, or working surface, is known as *face*.

Fig. 7.1 Designs of some early hand instruments. These instruments were individually handmade, variable in design, and cumbersome to use. Because of the nature of the handles, effective sterilization was a problem.

Clinical Notes

Runout is the more significant term clinically because it is the primary cause of vibration during cutting and is the factor that determines the minimum diameter of the hole that can be prepared by a given bur. Because of runout errors, burs normally cut holes measurably larger than the head diameter.

Bur Blade Design

The actual cutting action of a bur (or a diamond) occurs in a very small region at the edge of the blade (or at the point of a diamond chip). In the high-speed range, this effective portion of the individual blade is limited to no more than a few thousandths of a centimeter adjacent to the blade edge. Figure 7.22 is an enlarged schematic view of this portion of a bur blade. Several terms used in the discussion of blade design are illustrated.

Each blade has two sides—the *rake face* (toward the direction of cutting) and the *clearance face*—and three important angles—the *rake angle*, the *edge angle*, and the *clearance angle*.

Rake angle The rake angle is the most important design characteristic of a bur blade. A rake angle is said to be negative when the rake face is ahead of the radius (from cutting edge to axis of bur), as illustrated in Figure 7.22. For cutting hard, brittle materials, a *negative rake angle* minimizes fractures of the cutting edge, increasing the tool life.

Edge angle Carbide bur blades have higher hardness and are more wear-resistant, but they are more brittle than steel blades and require greater edge angles to minimize fractures. Increasing the edge angle reinforces the cutting edge and reduces the likelihood for the edge of the blade to fracture.

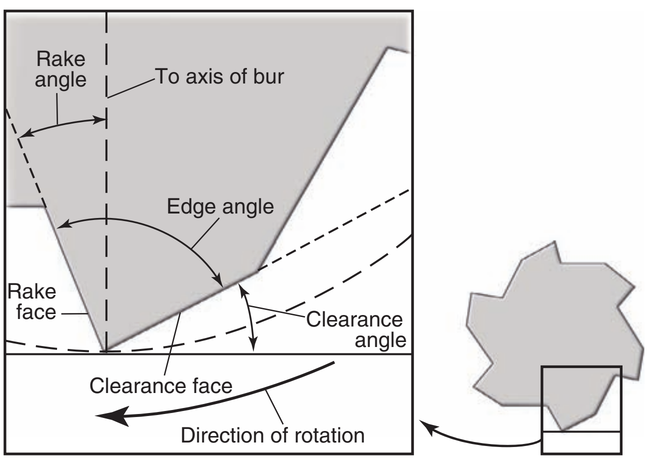


Fig. 7.22 Bur blade design. Schematic cross-section viewed from shank end of head to show rake angle, edge angle, and clearance angle.

Clearance angle The clearance angle eliminates rubbing friction of the clearance face, provides a stop to prevent the bur edge from digging into the tooth structure excessively, and provides adequate flute space or clearance space for the chips formed ahead of the following blade. An increase in the clearance angle causes a decrease in the edge angle.

Clinical Notes

- The three angles cannot be varied independently of each other.
- Carbide burs normally have blades with slight negative rake angles and edge angles of approximately 90 degrees.
- Their clearance faces either are curved or have two surfaces to provide a low clearance angle near the edge and a greater clearance space ahead of the following blade.

II. Diamond Abrasive Instruments

The second major category of rotary dental cutting instruments involves abrasive cutting rather than blade cutting. Abrasive instruments are based on small, angular particles of a hard substance held in a matrix of softer material. Cutting occurs at numerous points where individual hard particles protrude from the matrix, rather than along a continuous blade edge.

Terminology

Diamond abrasive instruments consist of three parts (Fig. 7.23):

1. Metal blank
2. Powdered diamond abrasive
3. Metallic bonding material that holds the diamond powder onto the blank.

The diamonds employed are industrial diamonds, either natural or synthetic, that have been crushed to powder, then carefully graded for size and quality.

The shape of the individual particle is important because of its effect on the cutting efficiency and durability of the instrument, but the careful *control of particle size* is probably of greater importance.

The diamonds generally are attached to the blank by electroplating a layer of metal on the blank while holding the diamonds in place against it.

Classification

Diamond instruments currently are marketed in myriad head shapes and sizes (Table 7.4) and in all of the standard shank designs. Most of the diamond shapes parallel those for burs (Fig. 7.24).

CHAPTER

9

Fundamentals of Tooth Preparation and Pulp Protection

"Success is neither magical nor mysterious… Success is the natural consequence of consistently applying the basic fundamentals."

—Jim Rohn

In the past, most restorative treatments were for caries, and the term *cavity* was used to describe a caries lesion that had progressed to the point that part of the tooth structure had been destroyed. The tooth was cavitated (a breach in the surface integrity of the tooth) and was referred to as a cavity. Likewise, when the affected tooth was treated, the cutting or preparation of the remaining tooth structure (to receive a restorative material) was referred to as cavity preparation. Currently, many indications for treatment are not related to carious destruction, and the preparation of the tooth no longer is referred to as cavity preparation, but as ***tooth preparation***.

Much of the scientific foundation of tooth preparation techniques was presented by Black.[1] Modifications of Black's principles of tooth preparation have resulted from the influence of: [2–6]

- Concepts professed by Bronner, Markley, J Sturdevant, Sockwell, and C Sturdevant.
- Improvements in restorative materials, instruments, and techniques.
- Increased knowledge and application of preventive measures for caries.

Tooth Preparation

Tooth preparation is defined as the mechanical alteration of a defective, injured, or diseased tooth such that placement of restorative material re-establishes normal form and function, including esthetic corrections, where indicated.

Conventional Preparation

In the past, most tooth preparations were precise procedures, usually resulting in uniform depths, particular wall forms, and specific marginal configurations. Such precise preparations are still required for amalgam, cast metal, and ceramic restorations and may be considered conventional preparations. Conventional preparations require specific wall forms, depths, and marginal forms because of the properties of the restorative material.

Modified Preparation

The use of adhesive restorations, primarily composites and glass ionomers, has allowed a reduced degree of precision of tooth preparations. Many composite restorations may require only the removal of the defect (caries, fracture, or defective restorative material) and friable tooth structure for tooth preparation, without specific uniform depths, wall designs, retentive features or marginal forms. This simplification of procedures results in a modified preparation and is possible because of the physical properties of the composite material and the strong bond obtained between the composite and the tooth structure (Table 9.1).

Much of this chapter presents information about the conventional tooth preparations because of the specificity required. The fundamental concepts relating to conventional and modified tooth preparation are the same:

1. All unsupported enamel tooth structures are normally removed.
2. Fault, defect, or caries is removed.
3. Remaining tooth structure is left as strong as possible.

ii. These enamel rods are buttressed on the preparation side by progressively shorter rods whose outer ends have been cut off but whose inner ends are on sound dentin (Fig. 9.5B). Because enamel rods usually are perpendicular to the enamel surface, the strongest enamel margin results in a cavosurface angle greater than 90 degrees (see Fig. 9.4).

2. An enamel margin composed of full-length rods that are on sound dentin but are not buttressed tooth-side by shorter rods also on sound dentin is termed *strong*. Generally, this margin results in a 90 degree cavosurface angle.
3. An enamel margin composed of rods that do not run uninterrupted from the surface to sound dentin is termed *unsupported*. Usually, this weak enamel margin either has a cavosurface angle less than 90 degrees or has no dentinal support.

Classification of Tooth Preparations

Classification of tooth preparations according to the diseased anatomic areas involved and by the associated type of treatment was presented by Black.[1] These classifications were designated as class I, class II, class III, class IV, and class V. Since Black's original classification, an additional class has been added, class VI.

Class I Preparations

All pit-and-fissure preparations are termed class I. These include preparations on:

1. Occlusal surfaces of premolars and molars
2. Occlusal two-thirds of the facial and lingual surfaces of molars
3. Lingual surfaces of maxillary incisors.

Class II Preparations

Preparations involving the proximal surfaces of posterior teeth are termed class II.

Class III Preparations

Preparations involving the proximal surfaces of anterior teeth that do not include the incisal angle are termed class III.

Class IV Preparations

Preparations involving the proximal surfaces of anterior teeth that include the incisal edge are termed class IV.

Class V Preparations

Preparations on the gingival third of the facial or lingual surfaces of all teeth are termed class V.

Class VI Preparations

Preparations on the incisal edges of anterior teeth or the occlusal cusp tips of posterior teeth are termed class VI.

Stages of Tooth Preparation

The tooth preparation procedure is divided into two stages, each with several steps. Each stage should be thoroughly understood, and each step should be accomplished as perfectly as possible. The stages are presented in the sequence in which they should be followed if consistent, ideal results are to be obtained. The stages and steps in tooth preparation are listed in Box 9.1.

Initial Tooth Preparation Stage

Initial tooth preparation involves the extension of the external walls of the preparation at a specified, limited depth so as to provide access to the caries or defect and to reach peripheral sound tooth structure. The placement and orientation of the preparation walls are designed to resist fracture of the tooth or restorative material from masticatory forces principally directed with the long axis of the tooth and to retain the restorative material in the tooth (except for a class V preparation).

Step 1: Outline Form and Initial Depth

The first step in initial tooth preparation is determining and developing the outline form while establishing the initial depth.

Box 9.1

Steps of tooth preparation

Initial tooth preparation stage
Step 1: Outline form and initial depth
Step 2: Primary resistance form
Step 3: Primary retention form
Step 4: Convenience form

Final tooth preparation stage
Step 5: Removal of any remaining infected dentin or old restorative material (or both), if indicated
Step 6: Pulp protection, if indicated
Step 7: Secondary resistance and retention forms
Step 8: Procedures for finishing external walls
Step 9: Final procedures—cleaning, inspecting, desensitizing

Definition

Establishing the outline form means:

1. Placing the preparation margins in the positions they will occupy in the final preparation except for finishing enamel walls and margins.
2. Preparing an initial depth of 0.2–0.5mm pulpally of the DEJ position or 0.8mm pulpally to normal root-surface position (no deeper initially whether in the tooth structure, air, old restorative material, or caries unless the occlusal enamel thickness is minimal, and greater dimension is necessary for the strength of the restorative material) (Fig. 9.6).

Principles

The three general principles on which outline form is established regardless of the type of tooth preparation being prepared are as follows:

1. All unsupported or weakened (friable) enamel usually should be removed.
2. All faults should be included.
3. All margins should be placed in a position to allow finishing of the margins of the restoration.

Factors

In determining the outline form of a proposed tooth preparation, certain conditions or factors must first be assessed. These conditions affect the outline form and often dictate the extensions.

i. The *extent of the caries lesion*, defect, or faulty old restoration affects the outline form of the proposed tooth preparation because the objective is to extend to sound tooth structure except in a pulpal direction.
ii. *Esthetic considerations* not only affect the choice of restorative material but also the design of the tooth preparation in an effort to maximize the esthetic result of the restoration.
iii. Correcting or improving *occlusal relationships* also may necessitate altering the tooth preparation to accommodate such changes, even when the involved tooth structure is not faulty (i.e. a cuspal form may need to be altered to effect better occlusal relationships).
iv. The desired *cavosurface marginal configuration* of the proposed restoration affects the outline form. Restorative materials that need beveled margins require tooth preparation outline form

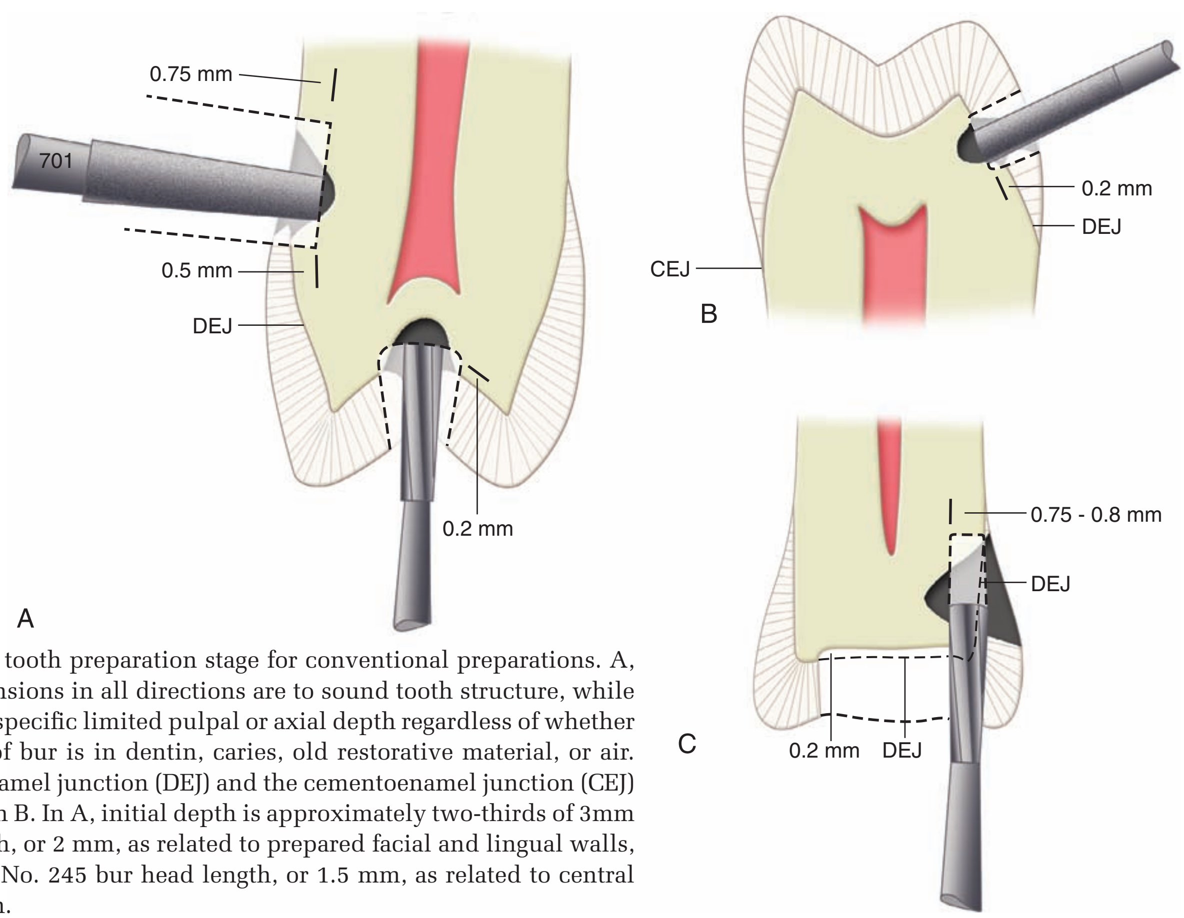


Fig. 9.6 Initial tooth preparation stage for conventional preparations. A, B, and C, Extensions in all directions are to sound tooth structure, while maintaining a specific limited pulpal or axial depth regardless of whether end (or side) of bur is in dentin, caries, old restorative material, or air. The dentinoenamel junction (DEJ) and the cementoenamel junction (CEJ) are indicated in B. In A, initial depth is approximately two-thirds of 3mm bur head length, or 2 mm, as related to prepared facial and lingual walls, but is half the No. 245 bur head length, or 1.5 mm, as related to central fissure location.

extensions that must anticipate the final cavo-surface position and form after the bevels have been placed.

Features

Generally, the typical features of establishing proper outline form and initial depth are:

1. Preserving cuspal strength
2. Preserving marginal ridge strength
3. Minimizing faciolingual extensions
4. Connecting two close (<0.5mm apart) defects or tooth preparations
5. Restricting the depth of the preparation into dentin.

Outline form and initial depth for pit-and-fissure lesions

Outline form and initial depth in pit-and-fissure preparations are controlled by three factors:

1. Extent to which the enamel has been involved by the carious process
2. Extensions that must be made along the fissures to achieve sound and smooth margins
3. Limited bur depth related to the tooth's original surface (real or visualized if missing because of disease or defect) while extending the preparation to sound external walls that have a pulpal depth of approximately 1.5–2mm and usually a maximum depth into dentin of 0.2mm (see Fig.9.6A and B).

Rules for establishing outline form for pit-and-fissure tooth preparation

1. Extend the preparation margin until sound tooth structure is obtained, and no unsupported or weakened enamel remains.
2. Avoid terminating the margin on extreme eminences, such as cusp heights or ridge crests.
3. If the extension from a primary groove includes one half or more of the cusp incline, consideration should be given to capping the cusp. If the extension is two thirds, the cusp-capping procedure is most often the proper procedure (Fig. 9.7) to remove the margin from the area of masticatory stresses.
4. Extend the preparation margin to include all of the fissure that cannot be eliminated by appropriate enameloplasty (Fig. 9.8).
5. Restrict the pulpal depth of the preparation to a maximum of 0.2mm into dentin. To be as conservative as possible, the preparation for an occlusal surface pit-and-fissure lesion to be restored with amalgam is first prepared to a depth of 1.5mm, as measured at the central fissure.
6. When two pit-and-fissure preparations have less than 0.5mm of sound tooth structure between them, they should be joined to eliminate a weak enamel wall between them.
7. Extend the outline form to provide sufficient access for proper tooth preparation, restoration placement, and finishing procedures (see step 4: convenience form).

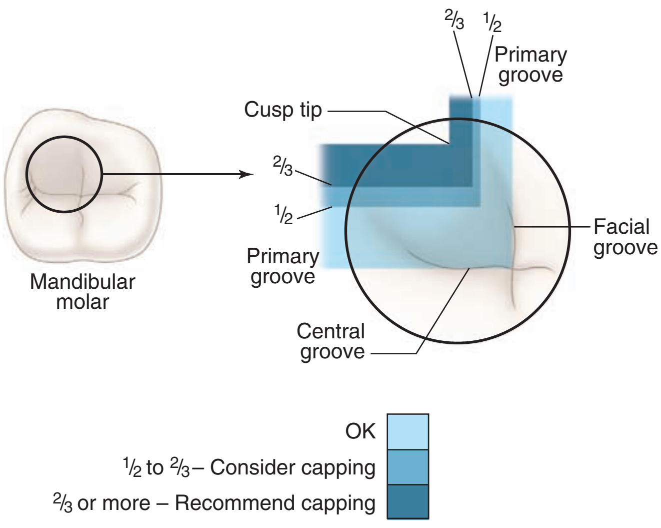


Fig. 9.7 Rule for cusp capping: If extension from a primary groove toward the cusp tip is no more than half the distance, no cusp capping should be done; if this extension is one half to two thirds of the distance, consider cusp capping; if the extension is more than two-thirds of the distance, usually cap the cusp.

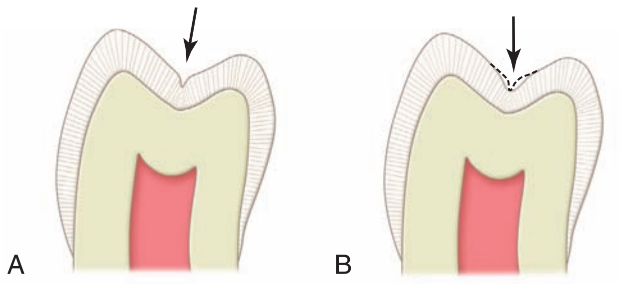


Fig. 9.8 A, Enameloplasty on area of imperfect coalescence of enamel. B, No more than one-third of the enamel thickness should be removed.

Enameloplasty

Definition Enameloplasty is a prophylactic procedure that involves the removal of a shallow, enamel developmental fissure or pit to create a *smooth, saucer-shaped* surface that is self-cleansing or easily cleaned (Fig. 9.8).

Indications

1. A fissure may be removed by enameloplasty if one third or less of the enamel depth is involved, without preparing or extending the tooth preparation.

CHAPTER

10

Fundamental Concepts of Enamel and Dentin Adhesion

"Imagination is the beginning of creation…you imagine what you desire…
You will what you imagine and at last …you create what you will."

—George Bernard Shaw

Basic Concepts of Adhesion

Definitions

The word adhesion comes from the Latin *adhaerere* ('to stick to'). Adhesion is defined as the state in which two surfaces are held together by interfacial forces, which may consist of valence forces, or interlocking forces or both (The American Society for Testing and Materials [Specification D 907]).[1]

Adhesive is a material, frequently a viscous fluid that joins two substrates together by solidifying, resisting separation and transferring a load from one surface to the other. Adhesive strength is the measure of the load-bearing capacity of an adhesive joint.[2]

Mechanisms of Dental Adhesion

In dentistry, bonding of resin-based materials to tooth structure is a result of four possible mechanisms:[3]

1. **Mechanical adhesion**: Interlocking of the adhesive with irregularities in the surface of the substrate, or *adherend*. This would involve the penetration of adhesive resin and formation of resin tags within the tooth surface.
2. **Adsorption adhesion**: Chemical bonding between the adhesive and the adherend; the forces involved may be primary valence forces (ionic and covalent) or secondary valence forces (hydrogen bonds, dipole interaction, or van der Waals). This would involve the chemical bonding to the inorganic component (hydroxyapatite) or organic components (mainly type I collagen) of tooth structure.
3. **Diffusion adhesion**: Interlocking between mobile molecules, such as the adhesion of two polymers through diffusion of polymer chain ends across an interface. This would involve the precipitation of substances on the tooth surfaces to which resin monomers can bond mechanically or chemically.
4. A ***combination*** of the previous three mechanisms.

Criteria for Optimal Adhesion

For good adhesion to take place, five fundamental attributes which are required are illustrated in Fig. 10.1.

Indications for Adhesive Dentistry

The availability of new scientific information on the etiology, diagnosis, and treatment of carious lesions and the introduction of reliable adhesive restorative materials have substantially reduced the need for extensive tooth preparations. Adhesive techniques also allow more conservative tooth preparations, less reliance on macro-mechanical retention, and less removal of unsupported enamel. With improvements in materials, indications for resin-based materials have progressively shifted from the anterior segment only to posterior teeth as well.

Adhesive restorative techniques currently are used for the following indications:

1. Restore class I, II, III, IV, V, and VI carious or traumatic defects

Classification of Dentinal Adhesives

We can divide the chronology of development of dentinal adhesives into historical and current options (Table 10.1). A complete listing of the chemical names mentioned in this chapter is provided in Table 10.2.

I. Historical Strategies

i. First Generation (1965)

Chemical

Surface-active co-monomer NPG-GMA[26,56]

Mechanism of action

Theoretically, this co-monomer could chelate with calcium on the tooth surface to generate water-resistant chemical bonds of resin to dentinal calcium.[57,58]

Brand Name

Cervident (S S White Burs, Inc, Lakewood, NJ)

Bond Strength

Only 2–3 MPa.[59]

Clinical result

Cervident had poor clinical results when used to restore noncarious cervical lesions without mechanical retention.[60]

TABLE 10.1

Classification of dentinal adhesives

1. Historical strategies: i. First generation (1965) ii. Second generation (1978) iii. Third generation (1984)
2. Current strategies: i. Etch and rinse adhesives a. Three step—etch and rinse adhesive (fourth generation) b. Two step—etch and rinse adhesive (fifth generation) ii. Self-etch adhesives a. Two component—self-etch adhesive (sixth generation) — Two step—two component—self-etch adhesive — One step—two component—self-etch adhesive b. Single component—one step—self-etch adhesive (seventh generation)

Table 10.2

Abbreviations commonly used in dentin/enamel adhesion literature and in this chapter

Abbreviation	Chemical name
Bis-GMA	Bisphenol-glycidyl methacrylate
EDTA	Ethylenediamine tetra-acetic acid
GPDM	Glycerophosphoric acid dimethacrylate
HEMA	2-Hydroxyethyl methacrylate
10-MDP	10-Methacryloyloxy decyl dihydrogen phosphate
4-META	4-Methacryloxyethyl trimellitate anhydride
MMEP	Mono (2-methacryloxy) ethyl phthalate
NPG-GMA	N-phenylglycine glycidyl methacrylate
PENTA	Dipentaerythritol penta-acrylate monophosphate
Phenyl-P	2-(Methacryloxy) ethyl phenyl hydrogen phosphate

ii. Second Generation (1978)

Chemical

It was a phosphate-ester material (phenyl-P and hydroxyethyl methacrylate [HEMA] in ethanol).

Mechanism of action

It was based on the polar interaction between negatively charged phosphate groups in the resin and positively charged calcium ions in the smear layer.[59]

Brand names

1. Clearfil Bond System F (Kuraray Co, Ltd, Osaka, Japan)
2. Scotchbond (3M EPSE Dental Products, St. Paul, MN)
3. Bondlite (Kerr Corporation, Orange, CA)
4. Prisma Universal Bond (DENTSPLY Caulk, Milford, DE).

Bond strength

Only 1–5 MPa.[4,43]

Clinical result

The in vitro performance of second-generation adhesives after 6 months was unacceptable.[61] The bonding material tended to peel from the dentin surface after water storage.[61,62] The in vivo performance of these materials was found to be clinically unacceptable 2 years after placement in cervical tooth preparations without additional retention.[63,64]

iii. Third Generation (1984)

Chemical

It was a phosphate-based material containing HEMA and a 10-carbon molecule known as *10-MDP*, which included long hydrophobic and short hydrophilic components.[57]

Mechanism of action

1. The concept of phosphoric acid-etching of dentin before application of a phosphate ester-type bonding agent was introduced by Fusayama et al in 1979.[65] Clearfil New Bond (Kuraray, Japan) was the only third generation bonding agent to follow the etched dentin philosophy.
2. Most of the other third-generation materials were designed not to remove the entire smear layer but, rather, to modify it and allow the penetration of acidic monomers, such as phenyl-P or PENTA.

Brand names

1. Clearfil New Bond (Kuraray Co, Ltd, Osaka, Japan)
2. Scotchbond 2 (3M ESPE Dental Products)

Clinical result

Clinical results were mixed, with some reports of good performance and some reports of poor performance.[63,64]

II. Current Strategies for Resin–Dentin Bonding

i. Etch and Rinse Adhesives

Concept

The smear layer is considered to be an obstacle that must be removed to permit resin bonding to the underlying dentin substrate.[42] The next generation of dentin adhesives was introduced for use on acid-etched dentin.[66] The clinical technique involves simultaneous application of an acid to enamel and dentin, this method was originally known as the *total-etch technique*. Now more commonly called *etch-and-rinse technique*, it was the most popular strategy for dentin bonding during the 1990s and remains somewhat popular today (Fig. 10.11).

Mechanism of action

Box 10.2 explains the mechanism of action of etch-and-rinse adhesives.

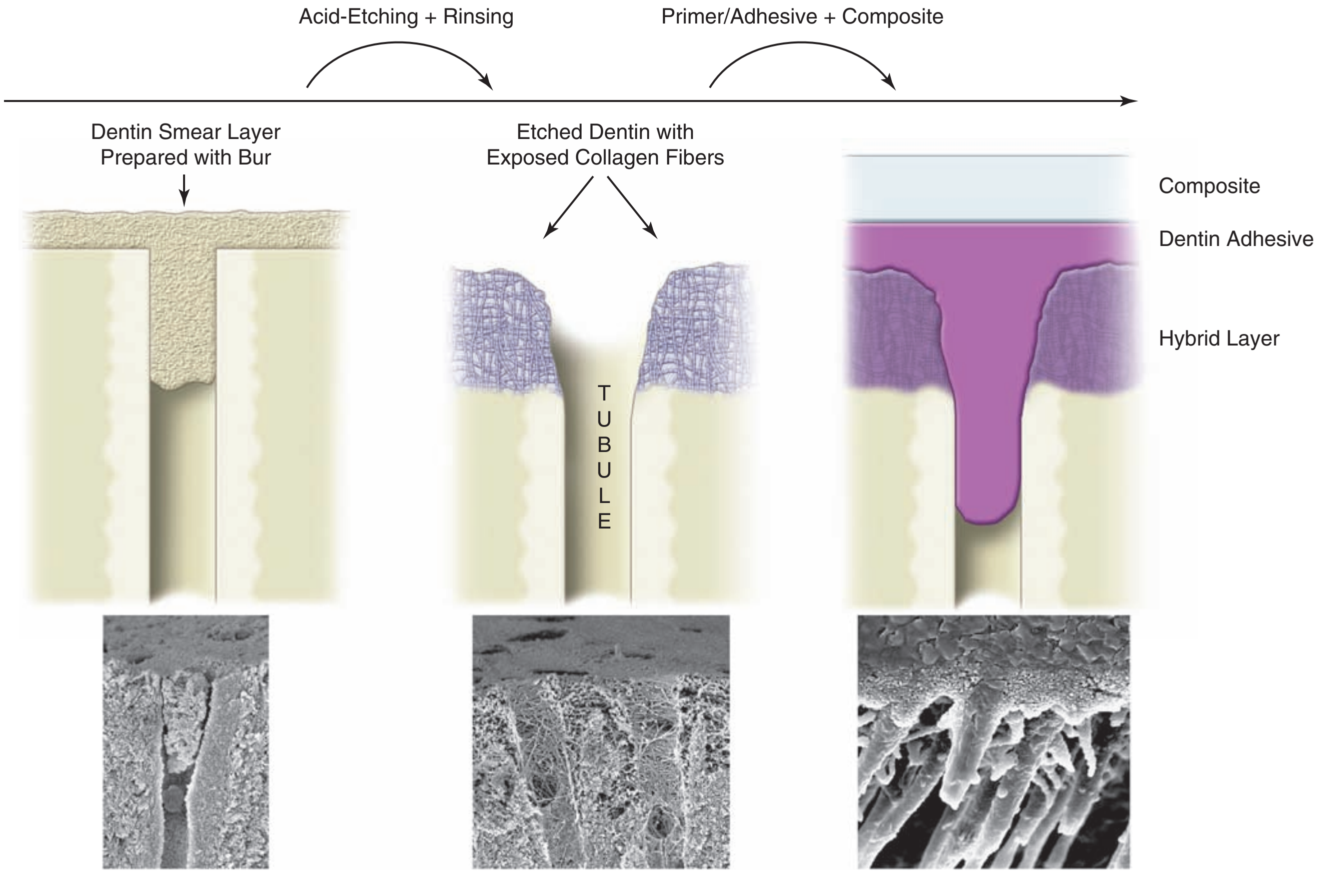


Fig. 10.11 Bonding of resin to dentin using an etch-and-rinse technique.

CHAPTER

13

Class III and IV Direct Composite Restorations

"A thing of beauty is a joy forever."

—John Keats

Class III and IV Direct Composite Restorations

This chapter presents information about class III and IV direct composite restorations (Fig. 13.1).

Indications

Class III and IV direct composite restorations are mainly indicated in the:

1. Restoration of caries lesions (class III and IV)
2. Anterior enamel and/or dentin crown fractures (class IV)

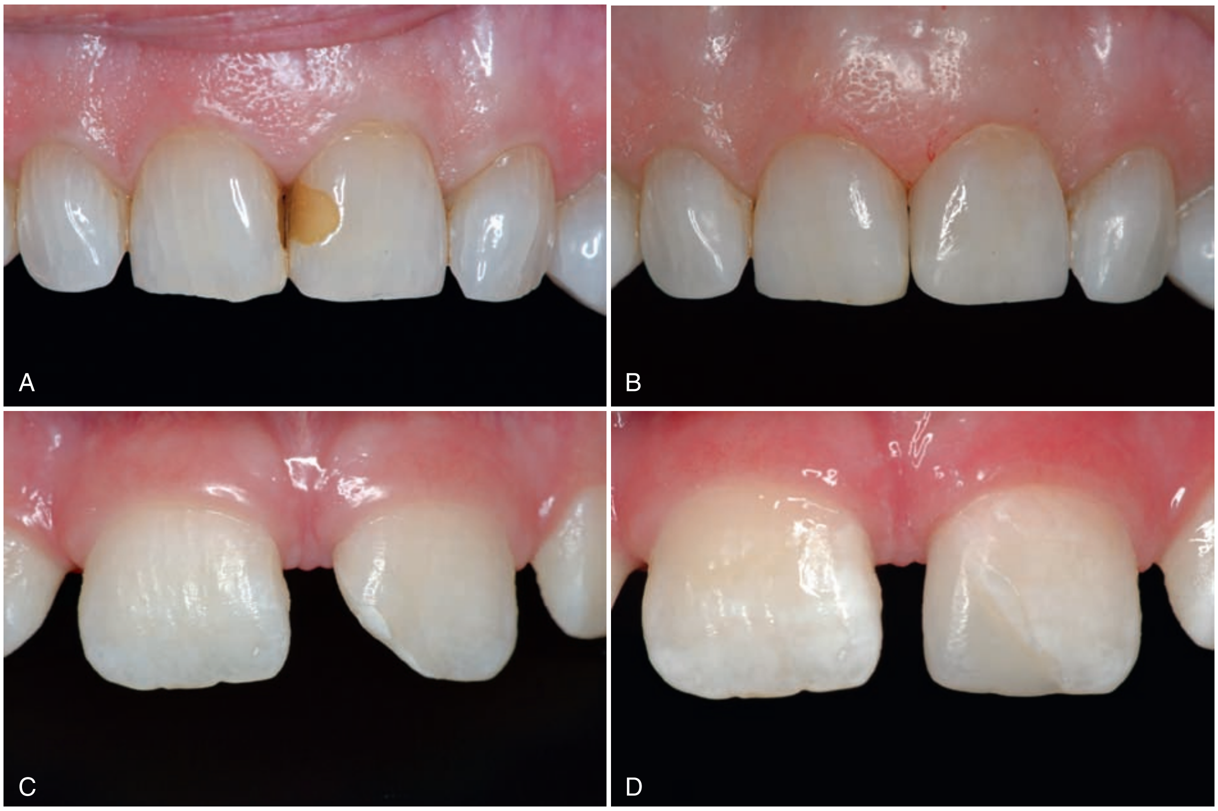


Fig. 13.1 Direct composite restorations before and after. **A** and **B,** Class III. **C** and **D,** Class IV.

Fig. 13.14 Class IV tooth preparation and restoration. **A,** Extraoral view, minor traumatic fracture. **B,** Intraoral view. **C,** Fractured enamel is roughened with a flame-shaped diamond instrument. **D,** The conservative preparation is etched, while adjacent teeth are protected with Mylar strip. **E–F,** Contouring and polishing the composite. **G,** Intraoral view of the completed restoration. **H,** Extraoral view.

CHAPTER

17

Additional Conservative Esthetic Procedures

"Beauty is harmony of all parts, in whatsoever subject it appears, fitted together with such proportion and connection, that nothing could be added, diminished or altered…. but for the worse."

—Leon Battiste Alberte (1610)

Significant improvements in tooth-colored restorative materials and adhesive techniques have resulted in numerous conservative esthetic treatment possibilities. This chapter presents conservative esthetic procedures in the context of their clinical applications.

Artistic Elements

In conservative esthetic dentistry certain basic artistic elements must be considered to ensure an optimal esthetic result**.** These elements include the following:

1. Shape or form
2. Symmetry and proportionality
3. Position and alignment
4. Surface texture
5. Color
6. Translucency.

I. Shape or Form

The shape of teeth largely determines their esthetic appearance. To achieve optimal dental esthetics, it is imperative that natural anatomic forms be achieved. Subtle variations in shape and contour produce very different appearances.

Cosmetic Contouring

Minor modification of existing tooth contours, sometimes referred to as *cosmetic contouring*, can effect a significant esthetic change. Reshaping enamel by *rounding incisal angles, opening incisal embrasures,* and *reducing prominent facial line angles* can produce a more youthful appearance (Fig. 17.1).

Illusion of Shape

Prominent areas of contour on a tooth typically are highlighted with direct illumination, making them more noticeable, whereas areas of depression or diminishing contour are shadowed and less conspicuous.

Illusion of narrowness

Compared with normal tooth contours (Fig. 17.2*A*), a tooth can be made to appear narrower by position-

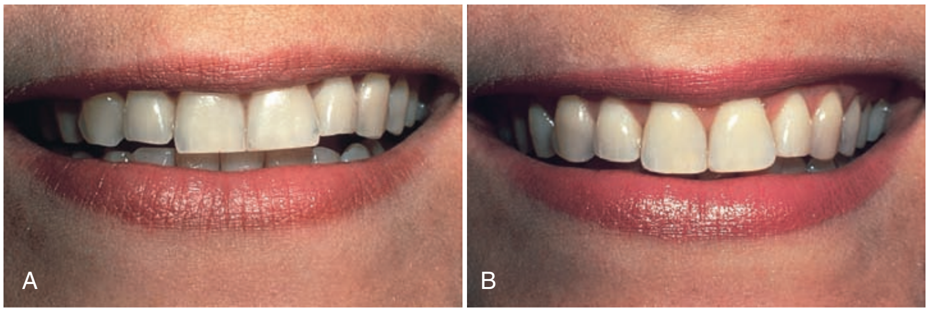


Fig. 17.1 Cosmetic contouring. **A,** Anterior teeth before treatment. **B,** By reshaping teeth, a more youthful appearance is produced.

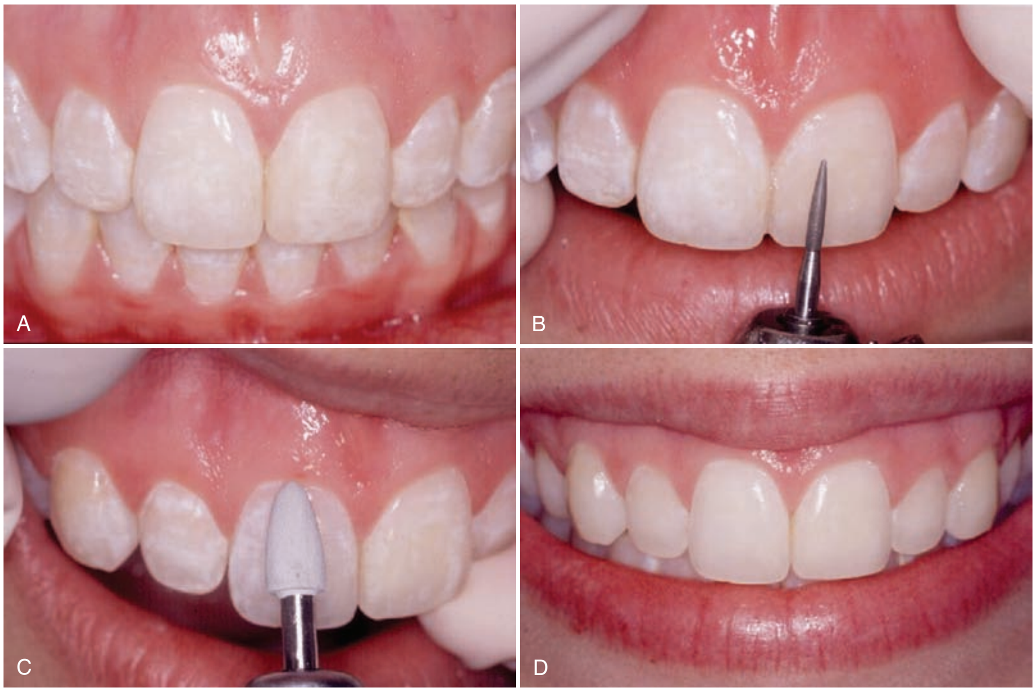


Fig. 17.24 Macroabrasion. **A,** Outer surfaces of maxillary anterior teeth are unesthetic because of superficial enamel defects. **B** and **C,** Removal of discoloration by abrasive surfacing and polishing procedures. **D,** Completed treatment revealing conservative esthetic outcome.

Veneers

Definition A veneer is a layer of tooth-colored material that is applied to a tooth to restore localized or generalized defects and intrinsic discolorations (Fig.17-25).

Indications

Common indications for veneers include teeth with facial surfaces are as follows (Fig. 17.26):
- Tooth malformation
- Discolored teeth
- Abraded or eroded facial surfaces
- Faulty restorations.

Types of veneers

1. Based on the *extent of the tooth involved*, veneers can be classified as:
   i. **Partial veneers:** Partial veneers are indicated for the restoration of localized defects or areas of intrinsic discoloration (Fig. 17.27).
   ii. **Full veneers**: Full veneers are indicated for the restoration of generalized defects or areas of intrinsic staining involving most of the facial surface of the tooth (Figs. 17.25 and17-28). Full veneers can be further subdivided based on the preparation design (Fig. 17.27) as:
      a. Window preparation
      b. Butt joint incisal preparation
      c. Incisal overlap preparation.
2. Based on the *type of material employed,* veneers can be classified as:
   i. Directly applied composite veneer
   ii. Processed composite veneer
   iii. Porcelain or pressed ceramic veneer.
3. Based on the *mode of fabrication* veneers can be classified into:
   i. Direct veneers
      a. Direct partial veneers
      b. Direct full veneers

Clinical Notes

- Although two appointments are required for indirect veneers, *chair time is reduced* because much of the work has been done in the laboratory.
- *Excellent results* can be obtained when proper clinical evaluation and careful operating procedures are followed.
- Indirect veneers are attached to the enamel by *acid etching* and *bonding* with light-cured resin cement.

1. No-prep Veneers

Concept

One approach being used for indirect veneers is to place them on teeth with *no tooth preparation*.

Indications

No-prep veneers are best used when teeth are inherently *undercontoured*, when *interdental spaces or open incisal embrasures* are present, or when both conditions exist. Example of successful no-prep veneers following these guidelines is seen in Figure 17.29.

Clinical Notes

- No-prep veneers can be *problematic* because of the following reasons:
  - First, no-prep veneers are inherently made *thinner* and, consequently, are more prone to fracture, especially during the try-in phase.
  - Second, for indirect no-prep veneers, interproximal areas are difficult to access for *proper finishing*.
  - Third, if case selection is not done properly and the teeth are already of normal contour, the resulting veneers inevitably will be *overcontoured*.

2. Etched Porcelain Veneers

Concept

The preferred type of indirect veneer is the etched porcelain (i.e. feldspathic) veneer. Porcelain veneers etched with hydrofluoric acid are capable of achieving *high bond strengths* to the etched enamel via a resin-bonding medium.[27–29] Etched porcelain veneers are *highly esthetic, stain resistant*, and *periodontally compatible*.

Clinical procedure

Step 1: Preoperative considerations

i. A consult appointment is always recommended for *shade selection, intraoral photographs*, and impressions for *diagnostic models* and occlusal records.
ii. An *incisal reduction index* is always recommended to accurately gauge the amount of incisal reduction during the preparation of teeth for etched porcelain veneers (Fig. 17.30*B* through *H*).

Step 2: Instrumentation

The veneer preparation is made with a *tapered, rounded-end diamond instrument*. A diamond with a tip diameter of 1.0–1.2 mm is recommended.

Step 3: Clinical considerations

i. The intraenamel preparations are made to a depth of approximately *0.5–0.75 mm midfacially*, diminishing to a depth of *0.3–0.5 mm* along the gingival margins, depending on enamel thickness.
ii. Veneer interproximal margins should be located just *facial to the proximal contacts*.

Fig. 17.29 No-prep veneers placed on maxillary anterior teeth. **A,** Before treatment. **B,** Immediately after placement of the no-prep veneers. *(Courtesy of Dr Patricia Pereira).*

Fig. 17.30 *(continued)*

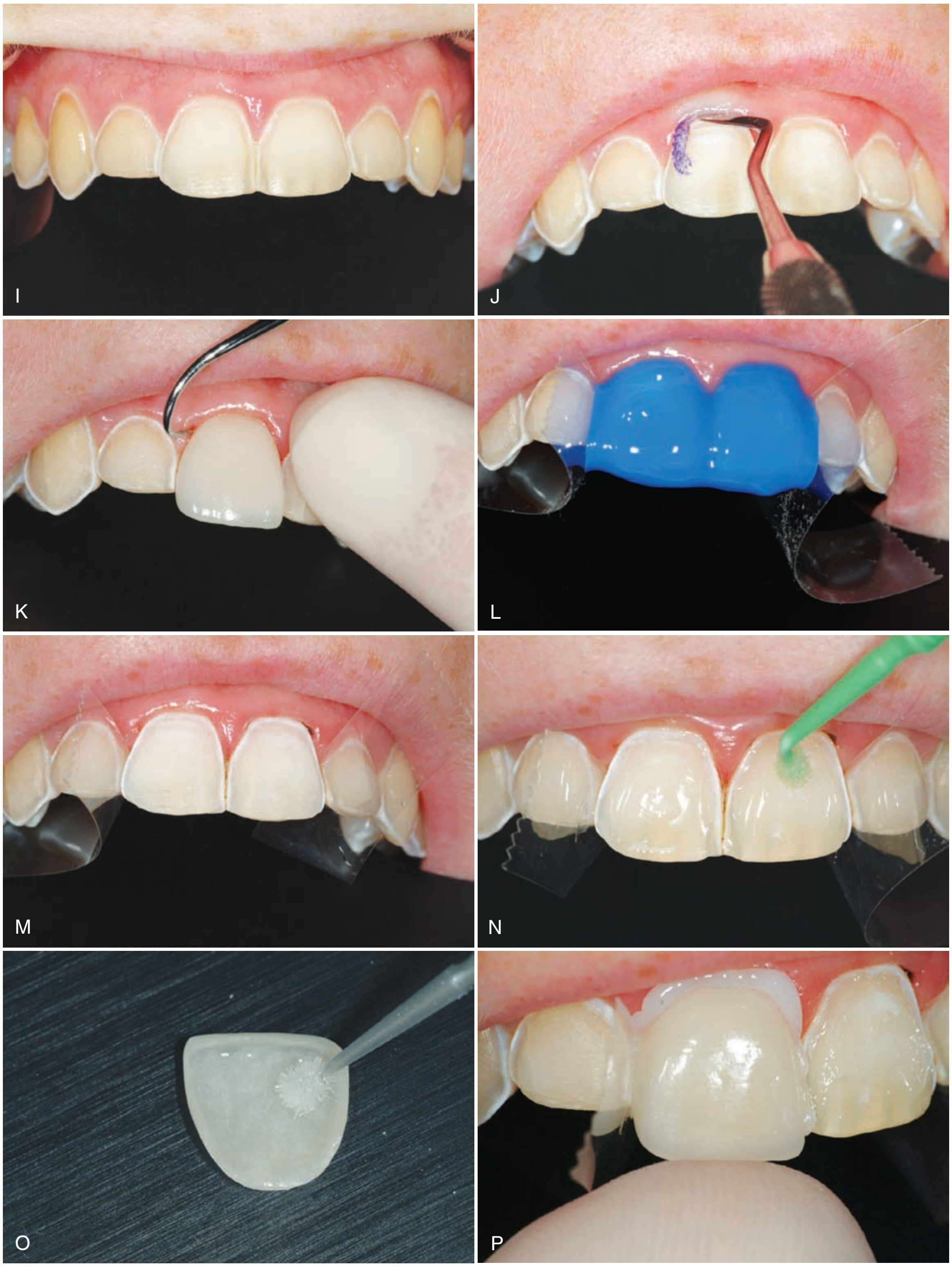


Fig. 17.30 *(continued)*

Fig. 17.30 *(continued)*

CHAPTER

19

Introduction to Amalgam Restorations

"To study the phenomena of disease is to sail an uncharted sea...
While to study patients without books is not to go to sea at all...".

—Sir William Osler, 1901

Amalgam

Dental amalgam is a metallic restorative material composed of a mixture of silver-tin-copper alloy and mercury. The unset mixture is pressed (condensed) into a specifically prepared undercut tooth form and contoured to restore the tooth's form and function. When the material hardens, the tooth is functional again, restored with a silver-colored restoration (Fig. 19.1). Amalgam has been the subject of intense research and has been found to be safe and beneficial as a direct restorative material.[1–8]

Fig. 19.1 Clinical example of an amalgam restoration. *(From Hatrick CD, Eakle WS, Bird WF:* Dental Materials: Clinical Applications for Dental Assistants and Dental Hygienists*, ed 2, St. Louis, 2011, Saunders).*

Terminology

Amalgam technically means an alloy of mercury (Hg) with any other metal. Dental amalgam is an alloy made by mixing mercury with silver–tin dental amalgam alloy (Ag-Sn). In dentistry, it is common to use the term *amalgam* to mean dental amalgam.

Composition

Amalgam alloy is a silver–tin alloy to which varying amounts of copper (Cu) and small amounts of zinc (Zn) have been added.

Classification

The major approaches to the classification of amalgams are shown in Box 19.1:

Box 19.1

Classification of amalgam

1. Based on copper content
   - i. Conventional or low copper alloy
   - ii. High copper alloy
     - a. High copper admixed alloy
     - b. High copper unicompositional alloy
2. Based on amalgam alloy particle geometry and size
   - i. Lathe-cut alloy
     - a. Regular-cut
     - b. Fine-cut
     - c. Microfine-cut
   - ii. Spherical alloy
   - iii. Admixed alloy
3. Based on zinc content
   - i. Zinc containing alloy
   - ii. Zinc-free alloy
4. New amalgam alloys

Box 19.2

Basic setting reaction of amalgam

Alloy particles of amalgam + Mercury → Dental amalgam + Unreacted alloy particles

Since the original mixture contains a large excess of silver–tin alloy particles, only a minor portion of the outside of the particles is consumed during the reaction with mercury

↓

The unreacted portion of the original amalgam alloy particles remains as residual alloy particles, reinforcing the final structure

↓

The reaction products form a matrix surrounding the residual alloy particles

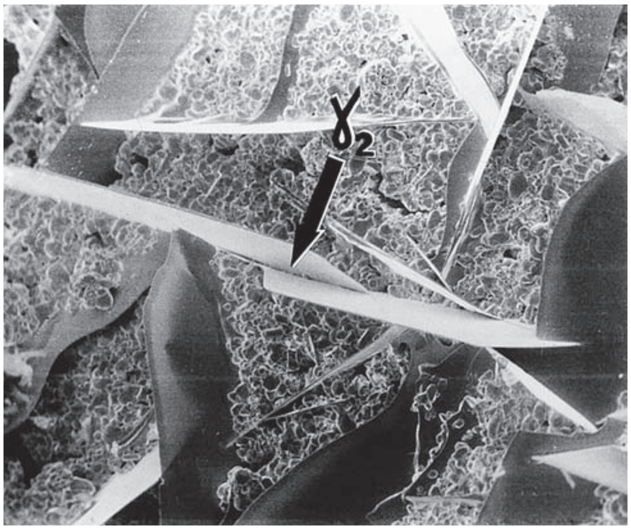


Fig. 19.4 Scanning electron microscopic view of tin–mercury (Sn-Hg) (γ_2) crystals that occur in a matrix of set low-copper amalgams. Note the blade-like crystals that penetrate amalgam and touch each other to create a continuous matrix (*arrow*). *(Courtesy of D F Taylor, School of Dentistry, University of North Carolina, Chapel Hill, NC).*

Table 19.2

Phases of amalgam

Silver–tin phase	γ (Gamma)	Ag_3Sn
Silver–mercury phase	γ_1	Ag_2Hg_3
Tin–mercury phase	γ_2	$Sn_{7-8}Hg$
Copper–tin phase	ε (Epsilon)	Cu_3Sn
Copper–tin phase	η (Eta)	Cu_6Sn_5

Box 19.3

Setting reaction of conventional low copper amalgam alloy

$$\underset{\gamma}{Ag_3Sn} + Hg \rightarrow \underset{\gamma_1}{Ag_2Hg_3} + \underset{\gamma_2}{Sn_8Hg} + \text{Unreacted } Ag_3Sn$$

- This process produces penetrating corrosion that generates a porous and spongy amalgam with minimal mechanical resistance. Two key features of this degradation process are:
  i. The corrosion-prone character of the tin–mercury phase *gamma-2 phase(γ_2)*.
  ii. The connecting path formed by the blade-like geometry of the crystals. Both these are eliminated by the use of more copper in the initial composition.

Clinical Notes

The tin-mercury gamma-2 phase (γ_2) is the weakest phase in dental amalgam and is responsible for the corrosion process.

II. High Copper Amalgam

High-copper amalgams set in a manner similar to low-copper amalgams except that tin–mercury reactions are suppressed by the preferential formation of copper–tin phases instead.

i. High Copper Admixed Alloy

In high copper admixed alloys the reaction takes place in two steps (see Box 19.4). There is elimination of gamma-2 phase, which is the weakest phase.

Box 19.4

Setting reaction of high-copper admixed alloy

Step 1

$$\underset{\gamma}{Ag_3Sn} + \text{Ag-Cu} + Hg \rightarrow \underset{\gamma_1}{Ag_2Hg_3} + \underset{\gamma_2}{Sn_8Hg} + Ag_3Sn + \text{Ag-Cu}$$

Step 2

$$\underset{\gamma_2}{Sn_8Hg} + \text{Ag-Cu} \rightarrow \underset{\gamma_1}{Ag_2Hg_3} + \underset{\eta}{Cu_6Sn_5} + \text{Unconsumed Ag-Cu and } Ag_2Hg_3$$

CHAPTER

20

Class I and II Amalgam Restorations

"Endurance is not just the ability to bear a hard thing, but to turn it into glory".

—William Barclay

Amalgam is used for the restoration of many carious or fractured posterior teeth and in the replacement of failed restorations. If properly placed, an amalgam restoration provides many years of service.[1–6] This chapter presents the techniques and procedures for class I and II amalgam restorations (Fig. 20.1). Class I restorations restore defects on the occlusal surface of posterior teeth, the occlusal thirds of the facial and lingual surface of molars, and the lingual surfaces of maxillary anterior teeth. Class II restorations restore defects that affect one or both of the proximal surfaces of posterior teeth.

Indications

Amalgam is indicated for the restoration of a class I and II defect when the defect:

1. Is not in an area of the mouth where esthetics is highly important
2. Is moderate to large
3. Is in an area that will have heavy occlusal contacts
4. Cannot be well isolated
5. Extends onto the root surface
6. Will become a foundation for a full coverage restoration
7. Is in a tooth that serves as an abutment for a removable partial denture.

Contraindications

Although amalgam has no specific contraindications for use in class I and II restorations, relative contraindications for use include:

1. Esthetically prominent areas of posterior teeth.
2. Small to moderate class I and II defects that can be well isolated.

Advantages

Primary advantages are the *ease of use* and the *simplicity* of the procedure. The placing and contouring of amalgam restorations are generally easier than those for composite restorations.[7,8]

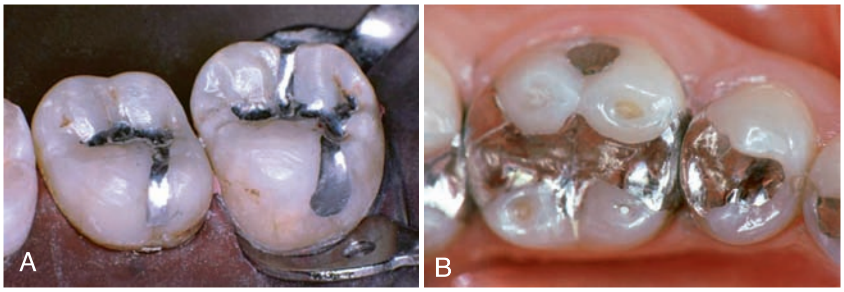


Fig. 20.1 Clinical examples of class I and II amalgam restorations. **A,** Class I amalgam in the occlusal surface of the first molar. **B,** Class II amalgams in a premolar and molar.

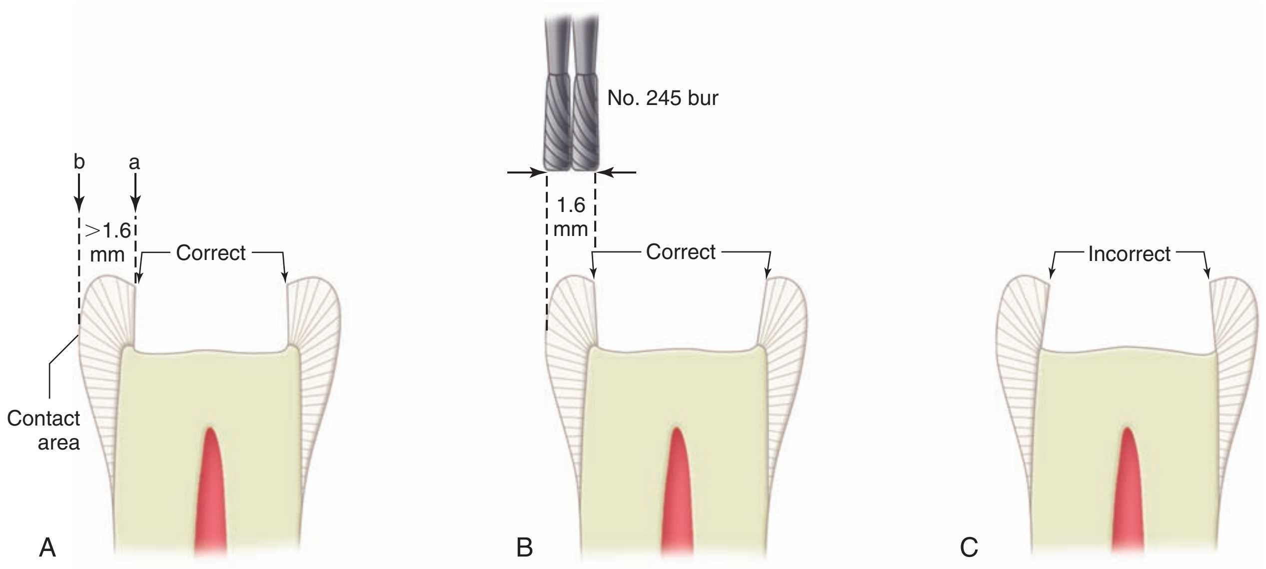


Fig. 20.5 The direction of the mesial and distal walls is influenced by the remaining thickness of the marginal ridge as measured from the mesial or distal margin (*a*) to the proximal surface (i.e. imaginary projection of proximal surface) (*b*). **A,** Mesial and distal walls should converge occlusally when the distance from *a* to *b* is greater than 1.6mm. **B,** When the operator judges that the extension will leave only 1.6mm thickness (two diameters of No. 245 bur) of marginal ridge (i.e. premolars) as illustrated here and in Fig.20.4*B* and *C*, the mesial and distal walls must diverge occlusally to conserve ridge-supporting dentin. **C,** Extending the mesial or distal walls to a two-diameter limit without diverging the wall occlusally undermines the marginal ridge enamel.

Step 3: Extension towards central fissure

- The bur's orientation and depth are maintained while extending along the central fissure toward the mesial pit, following the DEJ (see Fig. 20.4*E*).
- When the central fissure has minimal caries, one pass through the fissure at the prescribed depth provides the desired minimal width to the isthmus. Ideally, the width of the isthmus should be *just wider than the diameter of the bur*.

Clinical Notes

It is well established that a tooth preparation with a narrow occlusal isthmus is less prone to fracture.[19,20]

Step 4: Extension towards opposing marginal ridge (if required)

- If the fissure extends farther onto the marginal ridge, the long axis of the bur should be changed to establish a slight occlusal divergence to the mesial wall if the marginal ridge would be otherwise undermined of its dentinal support.
- Figure 20.5 illustrates the correct and incorrect preparation of the mesial and distal walls.

Step 5: Facial and lingual wall extension (if required)

The remainder of any occlusal enamel defects is included in the outline, and the *facial and lingual walls* are extended, if necessary, to remove enamel undermined by caries.[21]

Clinical Notes

The strongest and ideal enamel margin should be composed of full-length enamel rods attached to sound dentin, supported on the preparation side by shorter rods, also attached to sound dentin (Fig. 20.6).

Step 6: Enameloplasty (if required)

When the remaining fissure is no deeper than one-quarter to one-third the thickness of enamel, enam-

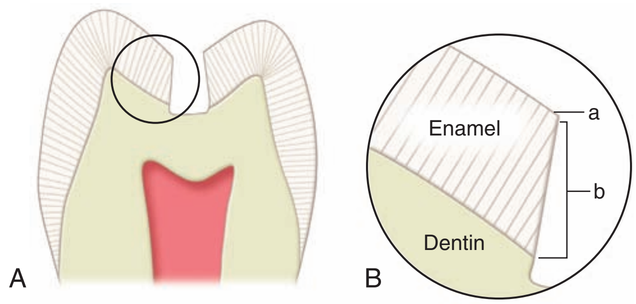


Fig. 20.6 **A** and **B,** The ideal and strongest enamel margin is formed by full-length enamel rods (*a*) resting on sound dentin supported on the preparation side by shorter rods, also resting on sound dentin (*b*).

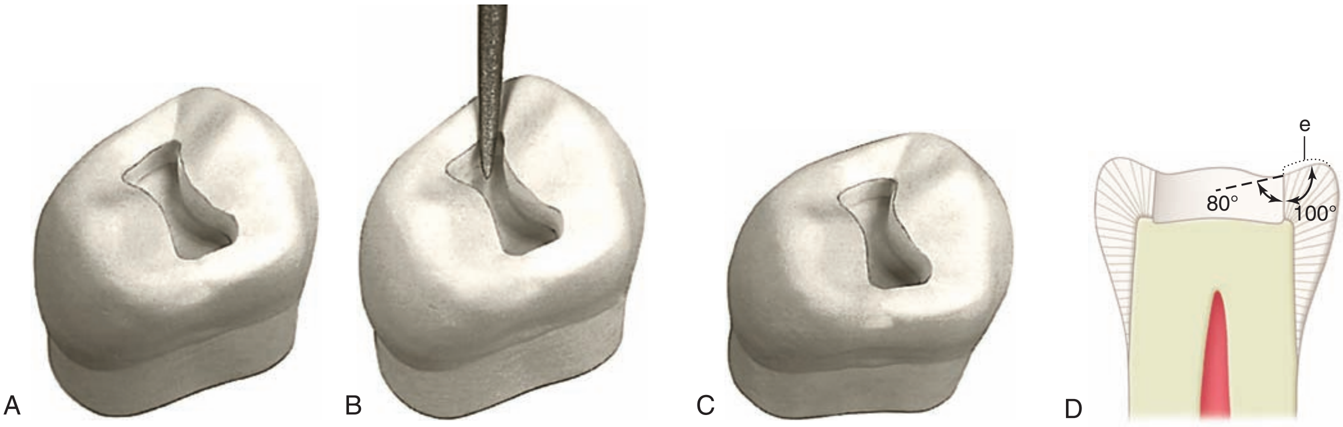


Fig. 20.7 Enameloplasty. **A,** Developmental defect at terminal end of fissure. **B,** Fine-grit diamond stone in position to remove the defect. **C,** Smooth surface after enameloplasty. **D,** The cavosurface angle should not exceed 100 degrees, and the margin–amalgam angle should not be less than 80 degrees. Enamel external surface (*e*) before enameloplasty.

eloplasty is indicated. *Enameloplasty* (see chapter 9) refers to eliminating the developmental fault by removing it with the side of a flame-shaped diamond stone, leaving a smooth surface (Fig. 20.7*A* through *C*). The surface left by enameloplasty should meet the tooth preparation wall, preferably with a cavosurface angle no greater than approximately 100 degrees; this would produce a distinct margin for amalgam of no less than 80 degrees (Fig. 20.7*D*).

II. Final tooth Preparation

The final tooth preparation includes:

1. Removal of remaining defective enamel and infected dentin on the pulpal floor

Removal of the remaining infected dentin (i.e. caries that extends pulpally from the established pulpal floor) is best accomplished using a *discoid-type spoon excavator* or a *slowly revolving round carbide bur* of appropriate size (Fig. 20.8).

Clinical Notes

- Using the *largest instrument* that fits the carious area is safest because it is least likely to penetrate the tooth in an uncontrolled manner.
- When removing infected dentin, the excavation should be stopped when the tooth structure feels *hard* or *firm* (i.e. the same feel as sound dentin). This situation often occurs before all lightly stained or discolored dentin is removed.[22]
- A *sharp explorer* or hand instrument is more reliable than a rotating bur for judging the adequacy of removal of infected dentin. These instruments should be used judiciously, however, in areas of possible pulpal exposure.

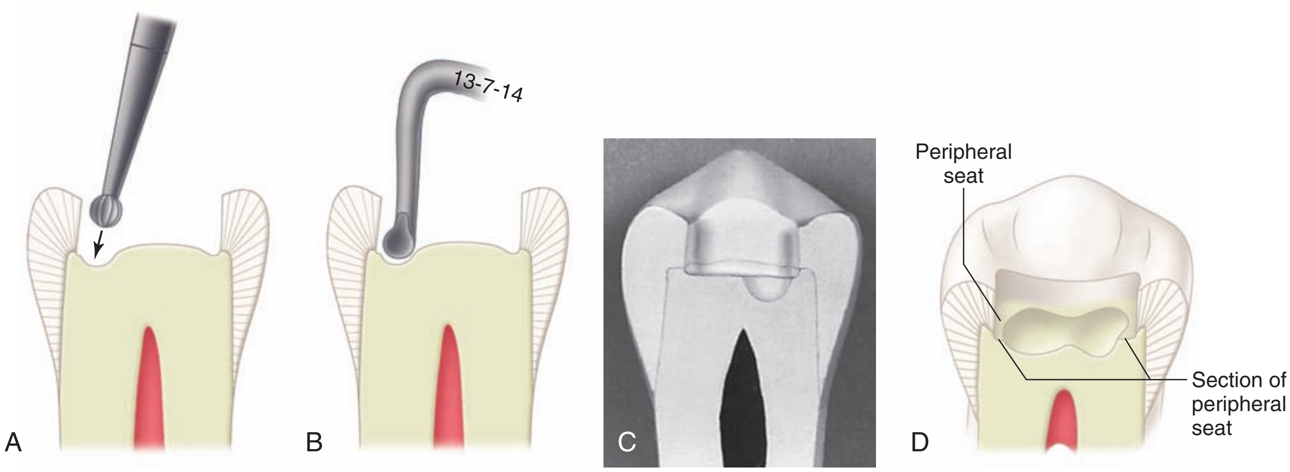


Fig. 20.8 **A** and **B,** Removal of dentinal caries is accomplished with round burs (*A*) or spoon excavators (*B*). **C** and **D,** The resistance form may be improved with a flat floor peripheral to the excavated area or areas.

CHAPTER

21

Complex Amalgam Restorations

"Simplicities are enormously complex".

—Richard O Moore

Complex posterior restorations are used to replace any missing structure of teeth that have fractured, have severe caries involvement, or have existing restorative material. These restorations usually involve the replacement of one or more missing cusps and require additional means of retention. This chapter describes the use of dental amalgam for complex direct posterior restorations.

Fig. 21.1 Mesio-occluso-disto-lingual (MODL) complex amalgam tooth No.16.

Indications

Complex posterior amalgam restorations should be considered when large amounts of tooth structure are missing and when one or more cusps need capping (Fig. 21.1).[1–4] Complex amalgams can be used as:

1. Definitive Final Restoration

Usually, a weakened tooth is best restored with a properly designed indirect (usually cast) restoration that prevents tooth fracture caused by mastication forces (see Chapter 24). When conventional retention features are not adequate because of insufficient remaining tooth structure, the retention form can be enhanced by using *pins, slots*, and *elective groove extensions* (Fig. 21.2).

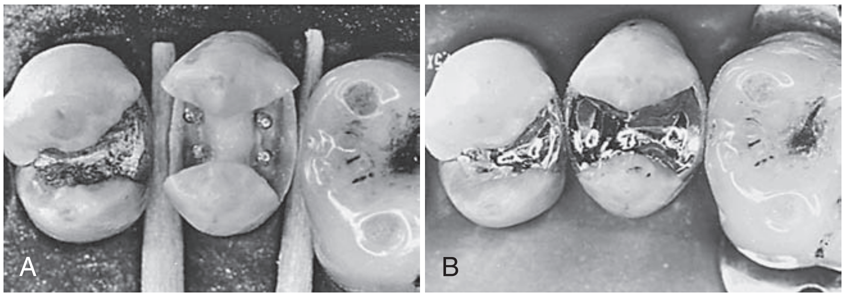


Fig. 21.2 Maxillary second premolar weakened by extensive caries and by the small fracture line extending mesiodistally on the center of the excavated dentinal wall. A, Minikin pins placed in the gingival floor improve resistance form after amalgam has been placed. B, Restorations polished.

2. **Resistance form**: Resistance form is more difficult to develop than when preparing a tooth for a cusp-capping onlay (skirting axial line angles of the tooth) or a full crown. The complex amalgam restoration does not protect the tooth from fracture as effectively as an extracoronal restoration.

Pin Retained Amalgam Restorations

Definition: A pin-retained restoration is defined as any restoration requiring the placement of one or more pins in dentin to provide adequate resistance and retention forms.

Advantages

1. Pins are used whenever *adequate resistance* and retention forms cannot be established with slots, locks, or undercuts only.[5]
2. The pin-retained amalgam is an important adjunct in the restoration of teeth with *extensive caries* or *fractures*.[6]
3. Amalgam restorations including pins have significantly *greater retention* compared with restorations using boxes only or restorations relying solely on bonding systems.[7]

Disadvantages

1. Preparing pinholes and placing pins may *create craze lines* or *fractures* and internal stresses in dentin.[8–10]
2. Pin retention increases the risk of *perforating* into the pulp or the external tooth surface.
3. The use of pins decreases the *tensile strength* of pin-retained amalgam restorations.[11–17]

Types of Pins

There are three types of pins for pin retained amalgam restorations (Fig. 21.5):
1. Self-threading pins
2. Cemented pins
3. Friction locked pins.

I. Self-threading Pins

- The *most frequently* used pin type is the self-threading pin.
- The pin-retained amalgam restoration using self-threading pins originally was described by Going in 1966.[18]
- The diameter of the prepared *pinhole is 0.0015–0.004 inch smaller than the diameter of the pin* (Table 21.1).
- The threads engage dentin as the pin is inserted, thus retaining it. The elasticity (resiliency) of dentin permits insertion of a threaded pin into a hole of smaller diameter.[19]
- A general guideline for *pinhole depth* is **2mm.**
- The Thread Mate System (TMS) (Coltène/Whaledent Inc., Mahwah, NJ) is the most widely used self-threading pin.

Thread Mate System (TMS)

Types
- Gold-plated stainless steel pins
- Titanium pins.

They are popular because of their:
- Versatility
- Wide range of pin sizes
- Color-coding system
- Greater retentiveness.

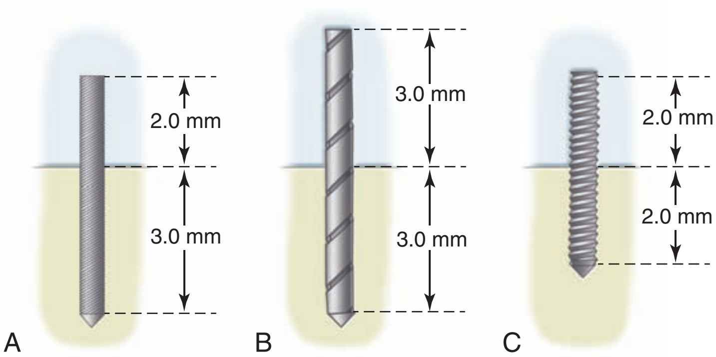


Fig. 21.5 Three types of pins. A, Cemented. B, Friction-locked. C, Self-threading.

II. Cemented Pins

1. In 1958, Markley described a technique for restoring teeth with amalgam and cemented pins using threaded (or serrated) stainless steel pins.
2. They are cemented into pinholes prepared *0.001–0.002 inch (0.025–0.05mm) larger than the diameter of the pin.*
3. The cementing medium may be any standard dental luting agent.

III. Friction Locked Pins

1. In 1966, Goldstein described a technique for the friction-locked pin.
2. The diameter of the prepared pinhole is *0.001 inch (0.025mm) smaller than the diameter of the pin.*
4. The pins are tapped into place, retained by the resiliency of the dentin.
5. They are two to three times more retentive than cemented pins.

Clinical Notes

- The self-threading pins are the most retentive of the three types of pins (Fig. 21.6), being three to six times more retentive than cemented pins.[20–22]
- Neither the cemented nor friction-locked pins are used often.

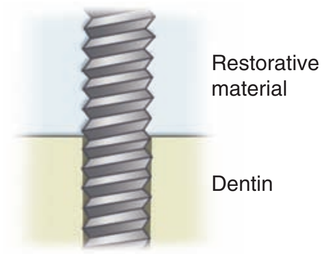


Fig. 21.6 The complete width of the threads of self-threading pins does not engage dentin.

Pin Placement Factors and Techniques

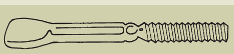
Pin Size

The four sizes of TMS pins which are available (Fig. 21.7), with their corresponding color-coded drills are (Table 21.1):

1. **Minikin** (0.019 inch [0.48mm]): They are usually selected to reduce the risk of dentin crazing, pulpal penetration, and potential perforation.
2. **Minim** (0.024 inch [0.61mm]): The Minim pins usually are used as a backup in case the pinhole for the Minikin is over-prepared or the pin threads strip dentin during placement and the Minikin pin lacks retention.
3. **Regular** (0.031 inch [0.78mm]): They are of the largest diameter, and are *rarely used* because a significant amount of stress and crazing, or

Table 21.1

The Thread Mate System (TMS) pins

Name	Illustration (not to scale)	Color code	Pin diameter (inches/mm)*	Drill diameter (inches/ mm)*	Total pin length (mm)	Pin length extending from dentin (mm)
Regular (standard)		Gold	0.031/0.78	0.027/0.68	7.1	5.1
Regular (self-shearing)		Gold	0.031/0.78	0.027/0.68	8.2	3.2
Regular (two-in-one)		Gold	0.031/0.78	0.027/0.68	9.5	2.8
Minim (standard)		Silver	0.024/0.61	0.021/0.53	6.7	4.7
Minim (two-in-one)		Silver	0.024/0.61	0.021/0.53	9.5	2.8
Minikin (self-shearing)		Red	0.019/0.48	0.017/0.43	7.1	1.5
Minuta (self-shearing)		Pink	0.015/0.38	0.0135/0.34	6.2	1

*1mm = 0.03937 inch

CHAPTER

24

Class II Cast Metal Restorations

"You arrive at precision...
When you become precise in your technique...".

The cast metal restoration is an *indirect restoration* that involves numerous steps and dental materials, with meticulous attention to detail. Typically, a dental laboratory is involved, and the dentist and the laboratory technician must be devoted to perfection. The high degree of satisfaction and service derived from a properly made cast metal restoration is a reward for the painstaking application required.[1]

Definitions

1. The class II *inlay* is an intracoronal cast metal restoration that involves the occlusal and proximal surfaces of a posterior tooth.
2. The *partial onlay* is a cast metal restoration that involves the occlusal and proximal surfaces of a posterior and covers and restores *at least one* but not all of the cusp tips of a posterior tooth.
3. The class II *onlay* is a cast metal restoration that involves the occlusal and proximal surfaces of a posterior tooth and caps *all of the cusps*.

Cast Metal Alloys

Cast metal restorations can be made from a variety of casting alloys. Their high compressive and tensile strengths are especially valuable in restorations that rebuild *most* or *all* of the occlusal surface.

At present, four distinct groups of alloys are in use for cast restorations:

1. Traditional high-gold alloys (*ADA specification No. 5*)
2. Low-gold alloys
3. Palladium–silver alloys
4. Base metal alloys (*most commonly used*).

Clinical Notes

- The American Dental Association (ADA) Specification No. 5 for dental casting gold alloys requires a minimum total gold-plus-noble-metals content of 75 weight percent (wt%). Such traditional high-gold alloys are unreactive in the oral environment and are some of the most biocompatible materials available to the restorative dentist.[2] However, their usage has drastically reduced due to the increasing cost of gold and other noble alloys.
- Each of the alternatives to high-gold alloys have associated problems of reduced performance, most commonly related to :
  - Decreased tarnish resistance
  - Decreased burnishability.[3]
  - Higher incidences of post-restorative allergy, most often exhibited by irritated soft tissue adjacent to the restoration.

Indications

i. Large Restorations

1. When proximal surface caries is extensive, the cast metal inlay is an alternative to amalgam or composite when the higher strength of a casting alloy is needed.
2. The cast metal onlay is often an excellent alternative to a crown for teeth that have been greatly weakened by caries or by large, failing restorations but where the facial and lingual tooth surfaces are relatively unaffected by disease or injury.

preparation for cast metal inlays and onlays. The recommended burs are:
   i. **No. 271 bur** (Brasseler USA, Inc)
   ii. **No. 169L bur** (Brasseler USA, Inc).
2. A *slender, fine-grit, flame-shaped diamond instrument* is used to place the marginal bevels. The recommended diamond is:

   No. 8862 bur (Brasseler USA, Inc).

The tooth preparation for a class II inlay is summarized in Table 24.1.

Clinical Notes

- The sides and end surface of the No. 271 bur meet in a *slightly rounded manner* so that sharp, stress-inducing internal angles are not formed in the preparation.[4]
- The burs used to develop the vertical walls are oriented to a *single 'draw' path*, usually the long axis of the tooth crown, so that the completed preparation has no undercuts (Fig. 24.1*C*).
- The gingival-to-occlusal divergence of these preparation walls may range from *2 to 5 degrees per wall* from the line of draw. If the vertical walls are unusually short, a maximum of 2 degree occlusal divergence is desirable to increase retention potential. As the occlusogingival height increases, the occlusal divergence should increase because lengthy preparations with minimal divergence (more parallel) may present difficulties during the seating and withdrawal of the restoration.
- Recommended dimensions and configurations of the burs to be used are shown in Figure 24.1*B.*

Table 24.1
Clinical steps in tooth preparation of a class II inlay

I. Initial preparation
a. Occlusal step
Step 1 Orienting the bur
Step 2 Occlusal punch cut
Step 3 Occlusal extension
Step 4 Dovetail retention
Step 5 Occlusal outline form
b. Proximal box
Step 1 Proximal ditch preparation
Step 2 Proximal box preparation
Step 3 Planing of the walls
Step 4 Placement of retention grooves
II. Final preparation
a. Removal of infected carious dentin and pulp protection
Step 1 Inspection
Step 2 Removal of infected caries
Step 3 Removal of old restorative material
Step 4 Pulp protection with light cure GIC
Step 5 Lining with calcium hydroxide (if required)
b. Preparation of bevels and flares
Step 1 Preparation of occlusal bevel
Step 2 Beveling the axio-pulpal line angle
Step 3 Preparing the secondary lingual flare
Step 4 Beveling the gingival margin
Step 5 Preparing the secondary facial flare

I. Initial Preparation

A. Occlusal Step

Step 1: Orienting the bur

The *No. 271 carbide bur* is held parallel to the long axis of the tooth crown.

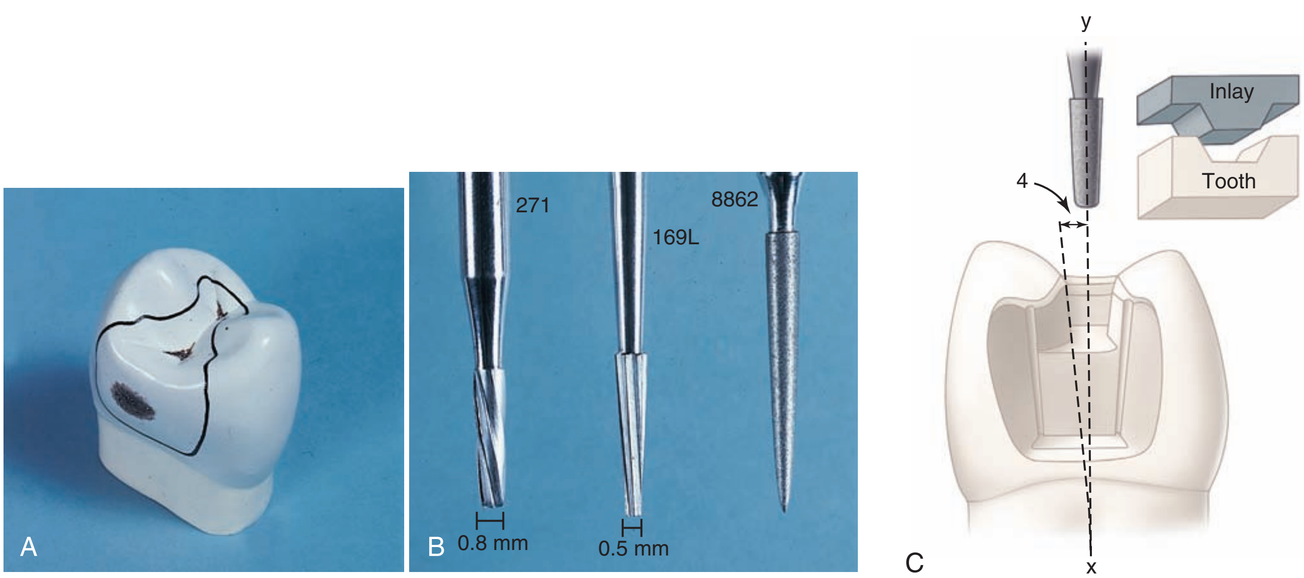


Fig. 24.1 **A,** Proposed outline form for disto-occlusal preparation in a maxillary premolar. **B,** Dimensions and configuration of No. 271, No. 169L, and No. 8862 instruments. **C,** Conventional 4 degree divergence from line of draw (line *xy*).

Clinical Notes

- The bur should be rotating at high speed (with air-water spray) before application to the tooth and should not stop rotating until it is removed; this minimizes perceptible vibration and prevents breakage or chipping of the bur blades.
- A general rule is to maintain the long axis of the bur parallel to the long axis of the tooth crown at all times (Fig. 24.2*B* and *C*).
- For mandibular molars and second premolars whose crowns tilt slightly lingually, this rule dictates that the bur should also be tilted slightly (5–10 degrees) lingually to conserve the strength of the lingual cusps (Fig. 24.2*D*).

Step 2: Occlusal punch cut

Enter the fossa or pit closest to the involved marginal ridge, using a *punch cut* to a depth of *1.5mm* to establish the depth of the pulpal wall (Fig. 24.2*A* and *B*).

Clinical Notes

In the initial preparation, this specified depth should not be exceeded, regardless of whether the bur end is in dentin, caries, old restorative material, or air.

Step 3: Occlusal extension

Maintaining the 1.5mm initial depth and the same bur orientation, the dentist extends the preparation

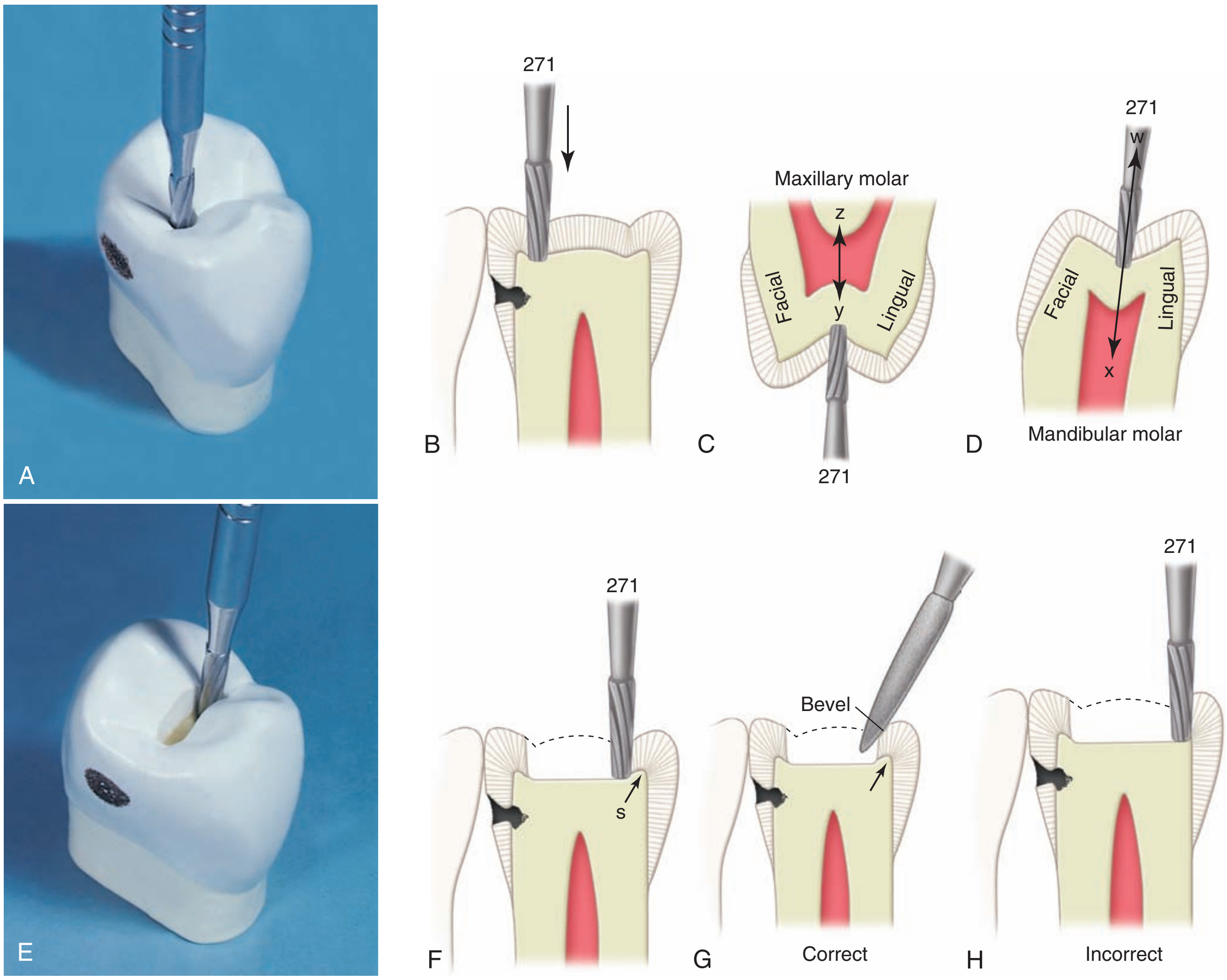


Fig. 24.2 **A** and **B,** Bur after punch cut to a depth of 1.5mm. **C,** For maxillary posterior teeth, the long axis of the bur should parallel the long axis of the tooth crown (line *yz*). **D,** For molar and second premolar teeth of mandibular dentition, the long axis of the bur should tilt slightly lingually to parallel the long axis of the tooth crown (line *wx*). **E** and **F,** Extending the mesial wall, taking care to conserve dentin that supports marginal ridge (*s*). **G,** The marginal bevel can provide additional extension. **H,** Improper extension that has weakened the marginal ridge.

Restorative Techniques for Cast Metal Restoration

The restorative technique for a cast metal restoration can be divided into the following stages as shown in Table 24.4.

I. Interocclusal Record

The maximum intercuspation interocclusal record can be made from one of several commercially available bite registration pastes. The most commonly used bite registration pastes are composed of *heavily filled polyvinyl siloxane (PVS) impression materials*. Several materials are available in cartridge systems that automatically mix the base and accelerator pastes together as they are expressed through a special disposable mixing tip (Fig. 24.18*A*).

Technique

1. The mixed impression material is dispensed directly onto the prepared teeth and their opponents, and then the patient closes the mouth completely (Fig. 24.18*B*, *C*).
2. The dentist observes teeth not covered by the bite registration paste to verify that teeth are in maximum intercuspation.
3. When the material has set, the dentist removes the interocclusal record and inspects it for completeness. When held up to a light, areas where the adjacent unprepared teeth have penetrated through the material should be seen (Fig. 24.18*D*).

TABLE 24.4

Stages of laboratory fabrication of a cast metal restoration

I.	Interocclusal record
II.	Custom temporary restoration
III.	Final impression i. Tissue retraction ii. Polyvinyl siloxane (PVS) impression a. Tray selection b. Impression technique
IV.	Working cast and dies
V.	Wax pattern
VI.	Spruing, investing casting, finishing, seating, adjusting and polishing the casting
VII.	Trying in the casting i. Preparing the mouth ii. Seating the casting and adjusting proximal contacts iii. Occluding the casting iv. Improving marginal adaptation
VIII.	Cementation

II. Custom Temporary Restoration

Between the time the tooth is prepared and the cast metal restoration is delivered, it is important that the patient be comfortable and the tooth be protected and stabilized with an adequate temporary restoration. The custom temporary restoration should satisfy the following requirements:

1. It should be *nonirritating* and protect the prepared tooth from injury.
2. It should *protect* and maintain the health of the periodontium.
3. It should maintain the *position* of the prepared, adjacent, and opposing teeth.
4. It should provide for *esthetic, phonetic,* and *masticatory* function, as indicated.
5. It should have adequate strength and retention to withstand the forces to which it will be subjected.

Temporaries can be fabricated by two methods:

1. **Direct technique**: Intraorally directly on the prepared teeth.
2. **Indirect technique**: Extraorally outside of the mouth using a postoperative cast of the prepared teeth.

Clinical Notes

The indirect technique is not as popular as the direct technique because of the increased number of steps and complexity in the former.

Technique for Direct Temporary Restoration

The direct temporary technique involves forming the temporary restoration directly on the prepared tooth (Fig. 24.19).

Advantages

1. The direct technique involves fewer steps and materials because no postoperative impression and gypsum cast are required.
2. It is much faster than the indirect technique.

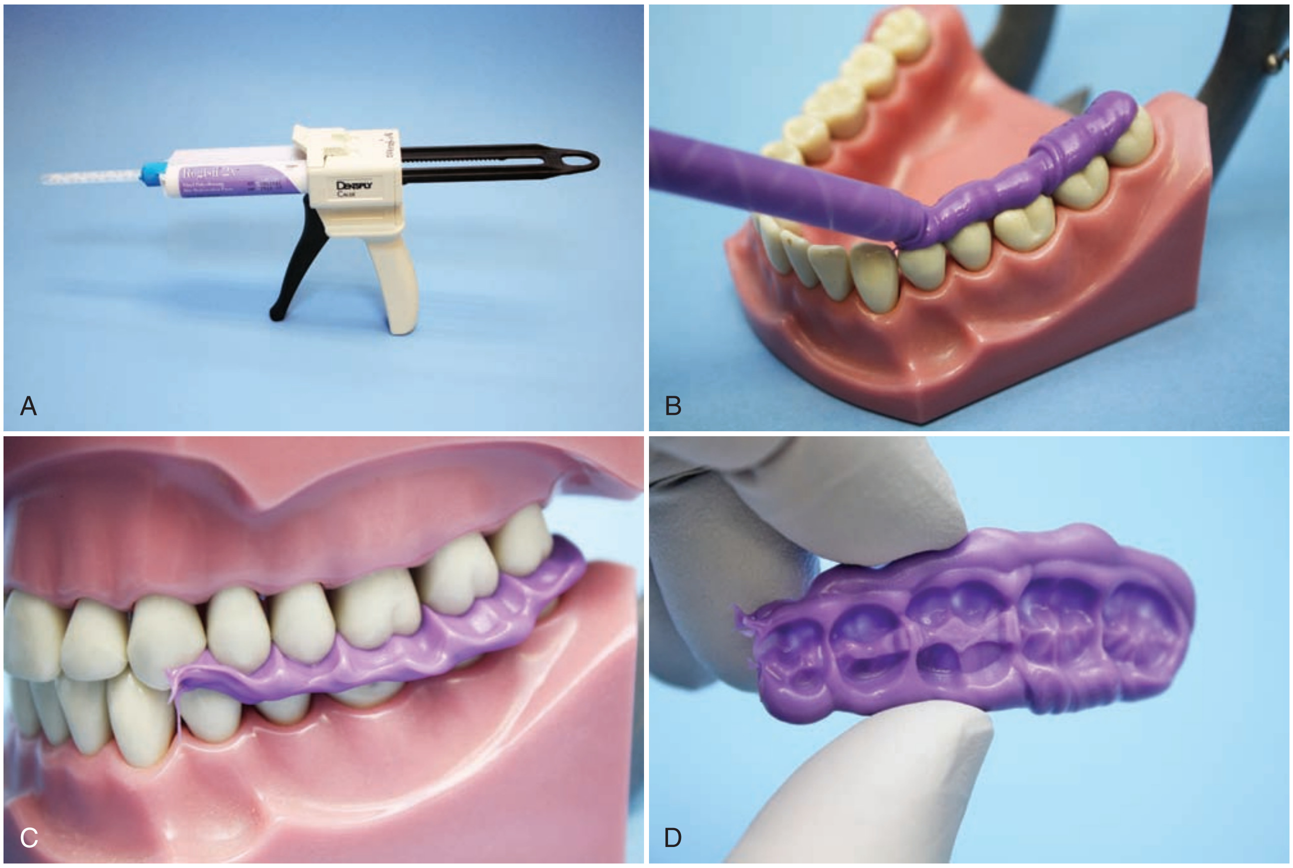


Fig. 24.18 Maximum intercuspation interocclusal record made with polyvinyl siloxane bite registration paste. **A,** One of many commercially available bite registration materials used in this technique. **B,** Using a cartridge dispenser and a disposable automixing tip, the base and accelerator pastes are automatically mixed and applied to the prepared teeth, their neighbors, and the opposing teeth. **C,** Have the patient close into maximum intercuspation position. Be sure that the adjacent unprepared teeth are touching in their normal relationships. **D,** Remove the maximum intercuspation interocclusal record carefully after it has set, and inspect it for completeness. Areas where the adjacent, unprepared teeth have penetrated through paste should be seen.

Disadvantages

1. There is a chance of locking hardened temporary materials into small undercuts on the prepared tooth and the adjacent teeth.
2. The marginal fit may be slightly inferior to the indirect technique.
3. It is more difficult to contour the temporary restoration without the guidelines offered by the postoperative cast.[7]

Technique

1. **Step 1**: Forming the temporary restoration directly on the prepared tooth requires the *preoperative impression*.
2. **Step 2**: Trial-fitting seats the preoperative impression onto teeth to verify that it seats completely.
3. **Step 3**: The temporary material is mixed, following the manufacturer's instructions. Temporary materials that use automixing tips are especially convenient (Fig. 24.19*C*). The dentist places the material into the preoperative impression in the area of the prepared tooth, taking care not to entrap any air (Fig. 24.19*D*).
4. **Step 4**: The impression is placed on teeth, and the dentist ensures that it seats completely (Fig. 24.19*E*). Most temporary systems recommend

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V Gopikrishna, MDS, FISDR is currently serving as Professor at Thai Moogambigai Dental College, Dr MGR Educational and Research Institute University, Chennai, India. He is the Editor of two other textbooks; Preclinical Manual of Conservative Dentistry and Grossman's Endodontic Practice, 12/e. He is also the Editor-in-Chief of Journal of Conservative Dentistry (www.jcd.org.in). He is a prolific researcher with more than 50 publications in international and national journals of repute for which he was conferred the Fellowship award of ISDR. He is the Founder-Director of Root Canal Centre (www.rootcanalcentre.com), an exclusive endodontic - restorative treatment and training centre based at Chennai, India.

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