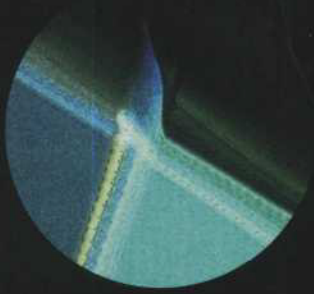
Fundamentals of Fixed Prosthodontics

Third Edition



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Preface

Fixed prosthodontics is the art and science of restoring damaged teeth with cast metal, metal-ceramic, or all-ceramic restorations, and of replacing missing teeth with fixed prostheses. Successfully treating a patient by means of fixed prosthodontics requires a thoughtful combination of many aspects of dental treatment: patient education and the prevention of further dental disease, sound diagnosis, periodontal therapy, operative skills, occlusal considerations, and sometimes, placement of removable complete or partial prostheses and endodontic treatment.

Restorations in this field of dentistry can be the finest service rendered for dental patients, or the worst disservice perpetrated upon them. The path taken depends upon one's knowledge of sound biological and mechanical principles, the growth of manipulative skills to implement the treatment plan, and the development of a critical eye and judgment for assessing detail.

As in all fields of the healing arts in recent years, there has been tremendous change in this area of dentistry Improved materials, instruments, and techniques have made it possible for today's operator of average skills to provide a service whose quality is on par with that produced only by the most gifted dentist of years gone by. This is possible, however, only if the dentist has a thorough background in the principles of restorative dentistry and an intimate knowledge of the techniques required.

This book was designed to serve as an introduction to the area of restorative dentistry dealing with fixed partial dentures and cast metal, metal-ceramic, and all-ceramic restorations. It should provide the background knowledge needed by the novice, as well as be a refresher for the practitioner or graduate student.

To provide the needed background for formulating rational judgments in the clinical environment, there are chapters dealing with the fundamentals of treatment planning, occlusion, and tooth preparation. In addition, sections of other chapters are devoted to the fundamentals of the respective subject. Specific techniques and instruments are discussed because dentists and dental students must deal with them in their daily work.

Alternative techniques are given when there are multiple techniques widely used in the profession. Frequently, however, only one technique is presented Cognizance is given to the fact that there is usually more than one acceptable way of accomplishing a particular operation. However, in the limited time available in undergraduate dental training, there is usually time for the mastery of only one basic technique for accomplishing each of the various types of treatment

An attempt has been made to provide a sound working background in the various facets of fixed prosthodontic therapy. Current information has been added to cover the increasing use of new cements, new packaging and techniques for the use of impression materials, and changes in the management of soft tissues for impression making. New articulators, facebows, and concepts of occlusion needed attention, along with precise ways of making removable dies. The increased usage of periodontally weakened teeth required some tips on handling teeth with exposed root morphology or molars that have lost a root.

Different ways of handling edentulous ridges with defects have given the dentist better control of the functional and esthetic outcome; no longer must metal or ceramics be relied on to somehow mask the loss of bone and soft tissue. The pages devoted to the technique for fabricating gold pontics with cemented, customized, prefabricated porcelain facings have been deleted.

The increased emphasis on esthetic restorations has necessitated expanding the subject of all-ceramic and metal-ceramic restorations from one chapter to three chapters. A chapter has been added to cover resin-bonded fixed partial dentures, a treatment modality whose strengths and shortcomings we are coming to recognize. Changes are based on recent research and on the experiences of the authors and their associates in the treatment of patients and the teaching of students.

Updated references are used to document the rationale for using materials and techniques and to familiarize the student with the literature in the various aspects of fixed prosthodontics. If more background information on specific topics is desired, several books are recommended:

For a detailed treatment of the subject of dental materials, refer to Dr Kenneth Anusavice's book, *Phillips'Science*

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of Dental Materials. For an in-depih study of occlusion, see Dr Peter Dawsons *Evaluation, Diagnosis, and Treatment of Occlusat Problems* (2nd ed) or Dr Jeffrey P. Okeson's *Management of Temporomandibular Disorders and Occlusion* (3rd ed). The topic of tooth preparations is discussed in greater detail in *Fundamentals of Tooth Preparations* by Shillmgburg, Jacobi, and Bracket!. For detailed coverage of occlusal morphology used in waxing restorations, consult *Guide to Occlusal Waxing* by Shillingburg, Wilson, and Morrison. A wealth of information concerning both the fabrication of porcelain restorations and the materials aspect of porcelain can be found in Dr John McLean's excellent works, *The Science and Art of Dental Ceramics, Volumes I and II;* in *Metal Ceramics—Principles and Methods of Makoto Yamamoto;* and in *Introduction to Metal Ceramic Technology* by Dr W. Patrick Naylor.

Two fine restorative dentists had an important influence on this book. Dr Robert Dewhirst and Dr Donald Fisher have been teachers, colleagues, and most important, friends. Many of their philosophies have steered us through the past 25 years. *The UCLA Fixed Prosthodontics Syllabus,* authored and edited by Dr Fisher and coauthored by Drs Dewhirst and Shillingburg in 1968, was the foundation upon which the first edition of this book was based in 1976.

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Chapter 1

An Introduction to Fixed Prosthodontics

The scope of fixed prosthodontic treatment can range from the restoration of a single tooth to the rehabilitation of the entire occlusion. Single teeth can be restored to full function, and improvement in cosmetic effect can be achieved. Missing teeth can be replaced with fixed prostheses that wilf improve patient comfort and masticatory ability, maintain the health and integrity of the dental arches, and, in many instances, elevate the patient's self-image.

It is also possible, by the use of fixed restorations, to render supportive and long-range corrective measures for the treatment of problems related to the temporomandibular joint and its neuromuscular components. On the other hand, with improper treatment of the occlusion, it is possible to create disharmony and damage to the stomatognathic system.

Terminology

A *crown* is a cemented extracoronal restoration that covers, or veneers, the outer surface of the clinical crown. It should reproduce the morphology and contours of the damaged coronal portions of a tooth while performing its function. It should also protect the remaining tooth structure from further damage.

If it covers all of the clinical crown, the restoration is a *full* or *complete veneer crown* (Fig 1-1). It may be fabricated entirely of a gold alloy or some other untarnishable metal, a ceramic veneer fused to metal, an all-ceramic material, resin and metal, or resin only. If only portions of the clinical crown are veneered, the restoration is called a *partial veneer crown* (Fig 1-2).

Intracoronal cast restorations are those that fit within the anatomic contours of the clinical crown of a tooth. *Inlays* may be used as single-tooth restorations for proximo-occlusal or gingival lesions with minimal to moderate extensions. They may be made of gold alloy (Fig 1-3, A) or a ceramic material (Fig 1-3, B). When modified with an occlusal veneer, the intracoronal restoration is called an *onlay* and is useful for restoring more extensively damaged posterior teeth needing wide mesio-occluso-distal restorations (Fig 1-4).

Another type of cemented restoration has gained considerable popularity in the past 10 years. The all-ceramic *laminate veneer,* or facial veneer (Fig 1-5), is used in situations requiring an improved cosmetic appearance on an anterior tooth that is otherwise sound. It consists of a thin layer of dental porcelain or cast ceramic that is bonded to the facial surface of the tooth with an appropriate resin.

The *fixed partial denture* is a prosthetic appliance, permanently attached to remaining teeth, which replaces one or more missing teeth (Fig 1-6). Although the term is preferred by prosthodontists, this type of restoration has long been called a *bridge.* "Bridge" is still in common enough usage that in the most recent listing of ADA insurance codes and nomenclature (1991), components of this restoration are catalogued under "bridge," and the term "fixed partial denture" does not appear in the list.[1] A tooth serving as an attachment for a fixed partial denture is called an *abutment.* The artificial tooth suspended from the abutment teeth is a *pontlc.* The pontic is connected to the fixed partial denture *retainers,* which are extracoronal restorations that are cemented to the prepared abutment teeth. Intracoronal restorations lack the necessary retention and resistance to be utilized as fixed partial denture retainers. The *connectors* between the pontic and the retainer may be rigid (ie, solder joints or cast connectors) or nonngid (ie, precision attachments or stress breakers).

Diagnosis

A thorough diagnosis must first be made of the patient's dental condition, considering both hard and soft tissues. This must be correlated with the individual's overall physical health and psychological needs. Using the diagnostic information that has been gathered, it is then possible to formulate a treatment plan based upon the patient's dental needs, mitigated to a variable degree by his or

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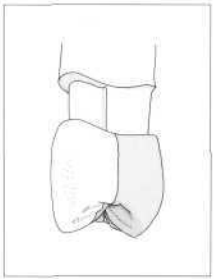


Fig 1-1 A full veneer crown covers all of the clinical crown of a tooth. The example is of a metal-ceramic crown.



Fig 1-2 A partial veneer crown covers only portions of the clinical crown. The facial surface is usually left unveneered.

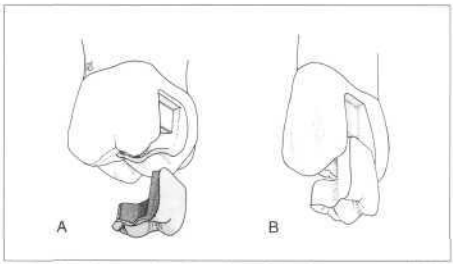


Fig 1-3 Inlays are intracoronal restorations with minimal to moderate extensions made of gold alloy (A) or a ceramic material (B).

her medical, psychological, and personal circumstances.

There are five elements to a good diagnostic workup in preparation for fixed prosthodontic treatment:

1. History
2. TMJ/occlussil evaluation
3. Intraoral examination
4. Diagnostic casts
5. Full mouth radiographs

History

It is important that a good history be taken before the initiation of treatment to determine if any special precautions are necessary. Some elective treatment might be eliminated or postponed because of the patient's physical or emotional health. It may be necessary to premedicate some patients for certain conditions or to avoid medication for others

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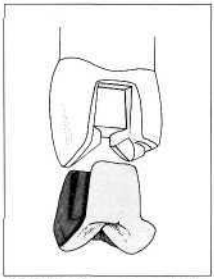


Fig 1-4 An onlay is an intracoronal restoration with an occlusal veneer.

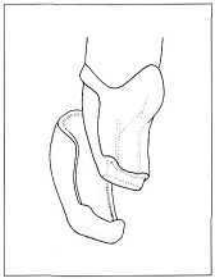


Fig 1-5 A laminatP veiwr is a thin layer of porcelain or cast ceramic that is bonded to the facial surface of a tooth with resin.

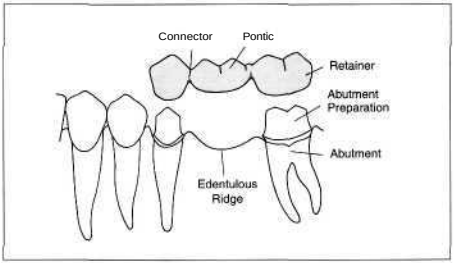


Fig 1-6 The components of a fixed partial deruurc.

It is not within the scope of this book to describe all the conditions that might influence patient treatment. However, there are some which occur frequently enough or pose a great enough threat to the patient's or dentist's well-being that they merit discussion. A history of infectious diseases such as serum hepatitis and acquired immunodeficiency syndrome must be known so that protection can be provided for other patients as well as office personnel.

There are numerous conditions of a noninfectious nature that also can be important to the patient's well-being. If a patient reports a previous reaction to a drug, it should be determined whether it was an allergic reaction or syncope resulting from anxiety in the dental chair. If there is any possibility of a true allergic reaction, a notation should be made on a sticker prominently displayed on the outside of the patient's record, so that the offending medication will never be administered or pre-

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scribed. Local anesthetics and antibiotics are the most common offenders.

The patient might also report a reaction to a dental material. Impression materials and nickel-containing alloys are leading candidates in this area. Do not engage in any "do-it-yourself" allergy testing to corroborate the patient's recollection of previous problems. It is possible to initiate a lile-threatening anaphylactic reaction if you challenge the patient's immune system with an allergen to which he or she has been previously sensitized.

The patient should be asked about medication currently being taken. All medications should be identified and their contraindications noted before proceeding with treatment. Question the patient about current medications at each subsequent appointment so that you will have up-to-date information on the medication regimen.

Patients who present with a history of cardiovascular problems may require special treatment. No patient with uncontrolled hypertension should be treated until the blood pressure has been lowered. Generally, a systolic reading above 160 mm of mercury or a diastolic reading above 95 preempts dental treatment and should be cause for referring the patient to his or her physician for evaluation and treatment.[2] Patients with a history of hypertension or coronary artery disease should not receive epinephrme. since this drug has a tendency both to increase heart rate and elevate blood pressure.

An individual with a prosthetic heart valve, a history of previous bacterial endocarditis, rheumatic fever with valvular dysfunction, most congenital heart malformations,[3,4] or mitral valve prolapse with valvular regurgitation[3,5] should be premedicated with amoxicillin or, in the case of allergy, erythromycin or clindamycin following the 1991 guidelines set by the American Heart Association.[3,4] Alternative regimens with other antibiotics administered by injection could be required. Patients with cardiac pacemakers[3,11] or prosthetic joints[6] probably will not require prophylaxis. It is best to check with the patient's physician if there is any question whether prophylactic antibiotics should be employed at all, or if an alternative antibiotic regimen should be utilized

A patient who is on an antibiotic regimen prescribed to prevent the recurrence of rheumatic fever is *not* adequately premedicated to prevent bacterial endocarditis.[3,4] Tetracyclines and sulfonamides are also *not* recommended."

Many patients with prosthetic heart valves are on Coumadm, an anticoagulant. These patients' physicians should be consulted before beginning any procedures that will cause even minor bleeding.

Epilepsy is another condition whose existence should be known. It does not contraindicate dentistry, but the dentist should know of its history in a patient so that appropriate measures can be taken without delay in the event of a seizure while the patient is in the chair. Steps should also be taken to control anxiety in these patients. Long, fatiguing appointments should be avoided to minimize the possibility of precipitating a seizure.

Diabetic patients are predisposed to periodontal breakdown or abscess formation.[7] A well-controlled diabetic may receive routine dental treatment. Those who are poorly controlled, tending toward elevated blood sugar, or hyperglycemia, could be adversely affected by the stress of a dental appointment to the point of falling into a diabetic coma.

Hypoglycemia can also cause problems. A controlled diabetic (on medication) who has missed a meal or has not eaten for several hours may suddenly feel light-headed and appear intoxicated. These patients usually carry some quick source of sucrose, such as candy, which should be administered. For this reason, dental treatment for the diabetic should interfere as little as possible with the patient's dietary routine, and the patient's stress level should be reduced. Any questions about the patient's ability to cope with dental treatment, and whether he or she is properly controlled, should be referred to a physician before proceeding.

The prolonged presence of xerostomia, or dry mouth, is conducive to greater carious activity and is therefore extremely hostile to the margins of cast metal or ceramic restorations. Patients who have had large doses of radiation in the oral region may have drastically diminished salivary flow.[8] It can also occur as a component of Sjogren's syndrome, an autoimmune, collagen disease.[9] It is frequently seen in conjunction with other autoimmune diseases, such as rheumatoid arthritis, lupus erythematosus, and scleroderma.[10]

There are also some 375 drugs capable of producing mild to severe xerostomia." Anticholinergics, anorectics, and antihypertensives may produce this effect. Antihistamines comprise the largest group of such drugs, and chronic allergy sufferers who use them over a prolonged time may suffer from a dry mouth.

The patient should be given an opportunity to describe the exact nature of the complaint that has brought him or her to the dental office for treatment. Attitudes about previous treatment and the dentists who have rendered it offer an insight into the patient's level of dental awareness and the quality of care expected. This will help the dentist to determine how much education the patient will require and how amenable the patient will be to cooperating with a good home-care program.

An effort should be made to get an accurate description of the patient's expectations of the treatment results. Particular attention should be paid to the cosmetic effect anticipated. A judgment must be made as to whether the patient's desires are compatible with sound restorative procedures. Possible conflicts in this area, as well as in the realm of personality, should be noted. The option of not providing care may need to be exercised with some patients.

TMJ/Occlusal Evaluation

Prior to the start of fixed prosthodontic procedures, the patient's occlusion must be evaluated to determine if it is

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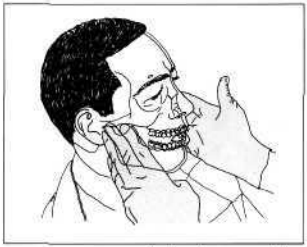


Fig 1-7 The joints are palpated as the patient opens and closes to detect iigns of dysfunction.

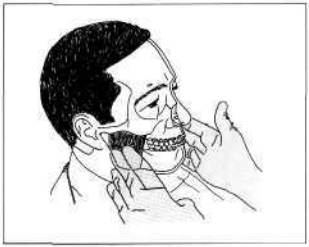


Fig 1-8 The masseter muscle can be palpated externally by placing your fingers over the lateral surfaces of the ramus of the mandible.

healthy enough to allow the fabrication of such restorations. If the occlusion is within normal limits, then all treatment should be designed to maintain that occlusal relationship. However, if the occlusion is dysfunctional in some manner, further appraisal is necessary to determine whether the occlusion can be improved prior to the placement of the restorations or whether the restorations can be employed in the correction of the occlusal problem.

Does the patient suffer from frequent occasions of head, neck, or shoulder pain? If so, an attempt must be made to determine the origin of such pain. Many patients suffer from undiagnosed muscle and/or joint dysfunction of the head and neck region, and such a history that has not been adequately diagnosed should be investigated further.

Next is an assessment of the temporomandibular joints themselves. Healthy temporomandibular joints function quietly with no evidence of clicking, crepitation, or limitation of movement on opening, closing, or moving laterally. Palpation of the joints as the patient opens and closes should reveal the existence of any signs of dysfunction (Fig 1-7). Many patients suffer from muscle pain as a result of parafunctional jaw activity related to stress or sensitivity to faults in their occlusion. Habits such as clenching the teeth and "playing with the bite" during the course of the daily routine may result in fatigue and muscle spasm. Observe the physical appearance and activities of this type of patient. Many times they will have a square-jowled appearance, with masseter muscles that are overdeveloped from hyperactivity. They may be clenching their teeth even as they converse with you.

A brief palpation of the masseter (Fig 1-8), temporalis (Fig 1-9), medial pterygoid (Fig 1-10), lateral pterygoid (Fig 1-11), trapezius (Fig 1-12), and sternocleidomastoid

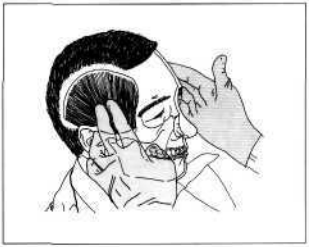


Fig 1-9 Fingers are placed over the patient's temples to feel the temporalis muscle.

(Fig 1-13) muscles may reveal tenderness. The patient may demonstrate limited opening due to spasm of the masseter and/or temporal muscles. This can be noted by asking the patient to open "all the way" (Fig 1-14). If it appears that the opening is limited, ask the patient to use a finger to indicate the area that hurts. If the patient touches a muscle area, as opposed to the temporomandibular joint, there is probably some dysfunction of the neuromuscular system (Fig 1-15).

Evidence of pain or dysfunction in either the temporomandibular joints or the muscles associated with the head and neck region is an indication for further evaluation prior to starting any fixed prosthodontic procedures.

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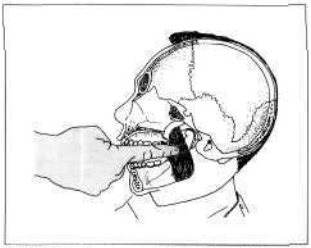


Fig 1-10 The index finger is used to touch the medial pterygoid muscle on the inner surface of the ramus.



Fig 1-11 The little finger is inserted facial to the maxillary teeth and around distal to the pterygomaxillary, or hamular, notch to palpate the lateral pterygoid muscle.

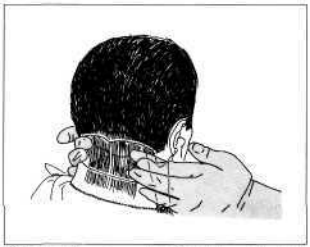


Fig 1-12 The trapezius muscle is felt at the base of the skull, high on the neck.



Fig 1-13 The sternocleidomastoid muscle is grasped between the thumb and forefingers on the side of the neck. The muscle can be accentuated by a slight turn of the patient's head.

Intraoral Examination

When the patient's mouth is examined, there are several observations to be made. The first of these is the patient's general oral hygiene. How much plaque can be found on the teeth, and in what areas? What is the general periodontal condition?

Check for a band of attached gingiva around all teeth, particularly around teeth to be restored with crowns. Mandibular third molars frequently do not have attached gingiva around the distal segment (30% to 60%). A prospective abutment that lacks the necessary attached tissue is a very poor candidate to receive a crown. The prospects of chronic inflammation occurring in response to any minute marginal irregularity in the crown are quite high.

The presence or absence of inflammation should be noted along with gingival architecture and stippling. The existence of pockets should be entered in the record and their location and depth charted. The presence and amount of tooth mobility should also be recorded, with special attention paid to any relationship with occlusal prematurities and to potential abutment teeth.

Examine edentulous ridges and note the relationship

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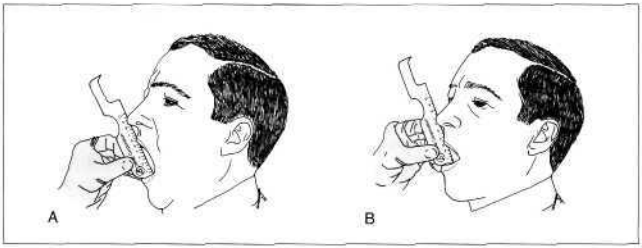


Fig 1-14 The distance between maxillary and mandibular incisors is measured when the patient is instructed to open "all the way" (A). If the patient can only open partway (B), the clinician should be determined.



Fig 1-15 Kopeninjt is limited, the patient should be instructed to use a finger lo indicate the area that hurts.

of spaces if there are more than one. What is the condition of prospective abutment teeth? Mote the presence and location of caries. Is it localized or widespread? Are there large numbers of gingival lesions and decalcification areas? The amount and location of caries, coupled with an evaluation of plaque retention, can offer some prognosis for new restorations that will be placed. It will also help to determine the preparation designs to be used.

Previous restorations and prostheses should be examined carefully. This will make it possible to determine their present suitability or their need to be replaced. It will also offer some prognosis for future work to be done.

Finally, an evaluation should be made of the occlusion. Are there large facets of wear? Are they localized or widespread? Are there any nonworking interferences? The amount of slide between the retruded position and the position of maximum intercuspation should be noted. Is the slide a straight one, or does the mandible deviate to one side or the other? The presence or absence of simultaneous contact on both sides of the mouth should be observed. The existence and amount of anterior guidance is also important. Restorations of anterior teeth must duplicate existing guidance or, in some patients, replace that which has been lost through wear or trauma.

Diagnostic Casts

Diagnostic casts are an integral part of the diagnostic procedures necessary to give the dentist as complete a perspective as possible of the patient's dental needs. To accomplish their intended goal, they must be accurate reproductions of the maxillary and mandibular arches, made from distortion-free alginate impressions. The casts should contain no bubbles as a result of faulty pouring, nor positive nodules on the occlusal surfaces ensuing from air entrapment during the making of the impression.

To gain the most from the diagnostic casts, they should be mounted on a semiadjustable articulator. When they have been positioned with a facebow and the articulator adjustments have been set by the use of lateral interocclusal records, or check bites, a reasonably accurate simulation of jaw movements will be possible. The articulator settings should be included in the patient's permanent record to facilitate resetting the instrument when restorations are fabricated for this

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patient at some future date. Finally, the mandibular cast should be set in a relationship determined by the patient's optimum condylar position (with the disc interposed) to better enable a critical occlusal analysis.

Articulated diagnostic casts can provide a great deal of information for diagnosing problems and arriving at a treatment plan. They allow an unobstructed view of the edentulous spaces and an accurate assessment of the span length, as well as the occlusogingival dimension. The curvature of the arch in the edentulous region can be determined, so that it will be possible to predict whether the pontic(s) will act as a lever arm on the abutment teeth.

The length of abutment teeth can be accurately gauged to determine which preparation designs will provide adequate retention and resistance. The true inclination of the abutment teeth will also become evident, so that problems in a common path of insertion can be anticipated, Mesiodistal drifting, rotation, and faciolingual displacement of prospective abutment teeth can also be clearly seen.

A further analysis of the occlusion can be conducted using the diagnostic casts. A thorough evaluation of wear facets—their numbers, size, and location—is possible when they are viewed on casts. Occlusal discrepancies can be evaluated and the presence of centric prematurities or excursive interferences determined. Discrepancies in the occlusal plane become very apparent on the articulated casts. Teeth that have supererupted into opposing edentulous spaces are easily spotted, and the amount of correction needed can be determined.

Situations calling for the use of pontics which are wider or narrower than the teeth that would normally occupy the edentulous space call for a diagnostic wax-up. Changes in contour plus widening or narrowing of an abutment tooth can also be tried and evaluated on a duplicate of the original cast. This enables the dentist and the patient to see how a difficult treatment will look when finished. The diagnostic wax-up, done in ivory wax, allows the patient to see all of the compromises that will be necessary.

It is far better to discover that the projected result is unsatisfactory to the patient before treatment is begun. If the patient is satisfied and the work proceeds, the wax-up will help the dentist plan and execute the preparations and the provisional, or temporary, restorations.

Full-Mouth Radiographs

Radiographs, the final aspect of the diagnostic procedure, provide the dentist with information to help correlate all of the facts that have been collected in listening to the patient, examining the mouth, and evaluating the diagnostic casts. The radiographs should be examined carefully for signs of caries, both on unrestored proximal surfaces and recurring around previous restorations. The presence of penapical lesions, as well as the existence and quality of previous endodontic treatments, should be noted.

General alveolar bone levels, with particular emphasis on prospective abutment teeth, should be observed. The crown-root ratio of abutment teeth can be calculated. The length, configuration, and direction of those roots should also be examined. Any widening of the periodontal membrane should be correlated with occlusal prematurities or occlusal trauma. An evaluation can be made of the thickness of the cortical plate of bone around the teeth and of the trabeculation of the bone.

The presence of retained root tips or other pathosis in the edentulous areas should be recorded. On many radiographs it is possible to trace the outline of the soft tissue in edentulous areas so that the thickness of the soft tissue overlying the ridge can be determined.

Protection Against Infectious Diseases

Protecting against cross-contamination of patients and preventing exposure of office staff to infectious diseases have become major concerns in dentistry in recent years. In particular, patients should be queried about a past history of either serum hepatitis (hepatitis B virus, or HBV) or human immunodeficiency virus (HIV). Although AIDS has received the greatest publicity and has generated near hysteria. HBV is the major infectious occupational hazard to health-care professionals.[12]

There is no evidence that either disease is contracted by casual contact with an infected person. However, the nature of dental procedures does produce the risk of contact with blood and tissues. A safe, effective vaccine against hepatitis B is available and is recommended by the Centers for Disease Control[13,14] and the ADA Council on Dental Therapeutics[15] for all dental personnel who have contact with patients.

While special precautions should be observed when treating patients with a history of either disease, *every* patient should be treated as being potentially infectious. Rubber gloves, a surgical mask or full-length plastic face shield, protective eyeglasses (if a shield is not used), and a protective uniform are recommended for the dentist and all other office personnel who will be in contact with the patient during actual treatment (Fig 1-16).

Concern for these matters does not end at the door to the operatory. Any item contaminated with blood or saliva in the operatory, such as an impression, is just as contaminated when it is touched outside the operatory. The days of casually munching on Doritos while waxing and handling a cast recently extracted from a bloody impression are a thing of the past. The specifics of decontaminating impressions will be covered in Chapter 17.

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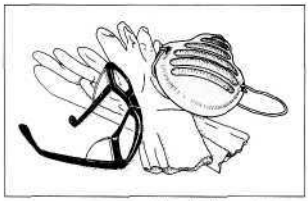


Fig 1-16 Rubber gloves, a surgical mask, and eye protection are important for safeguarding denial office personnel.

Steps must be taken in a receiving area of the laboratory to isolate and decontaminate items coming from the dental operatory.[15] An infection-control program should be established to protect laboratory personnel from infectious diseases, as well as to prevent cross-contamination that could affect a patient when an appliance returns from the laboratory to the operatory for insertion in the patient's mouth.[16] There is more to dental laboratory work than manipulating inert gypsum, wax. resins, metal, and ceramics.

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Chapter 9

Principles of Tooth Preparations

The design of a preparation for a casl restoration and the execution of thai design are governed by five principles:

1. Preservation of tooth structure
2. Retention and resistance
3. Structural durability
4. Marginal integrity
5. Preservation of the periodontium

Preservation of Tooth Structure

In addition to replacing lost tooth structure, a restoration must preserve remaining tooth structure. Intact surfaces of tooth structure that can be maintained while producing a strong, retentive restoration should be saved if patient acceptance and retention requirements will permit it. Whole surfaces of tooth structure should not be needlessly sacrificed to the bur in the name of convenience or speed.

Preservation of tooth structure in some cases may require that limited amounts of sound tooth structure be removed to prevent subsequent uncontrolled loss of larger quantities of tooth structure. This is the rationale for the removal of 1 to 1.5 mm of occlusal tooth structure when preparing a tooth for an MOD onlay. The metal on the occlusal surface can protect against dramatic failures, such as fracture of tooth structure, as well as the less obvious failures that may be occasioned by the flexing of tooth structure.

Retention and Resistance

For a restoration to accomplish its purpose, it must stay in place on the tooth. No cements that are compatible with living tooth structure and the biologic environment of the oral cavity possess adequate adhesive properties to hold a restoration in place solely through adhesion. The geometric configuration of the tooth preparation must place the cement in compression to provide the necessary retention and resistance

Retention prevents removal of the restoration along the path of insertion or long axis of the tooth preparation. *Resistance* prevents dislodgment of the restoration by forces directed in an apical or oblique direction and prevents any movement of the restoration under occlusal forces. Retention and resistance are interrelated and often inseparable qualities.

The essential element of retention is two opposing vertical surfaces in the same preparation. These may be external surfaces, such as the buccal and lingual walls of a full veneer crown (Fig 9-1, A). An extracoronal restoration is an example of veneer, or sleeve, retention {Fig 9-1, B). The opposing surfaces can also be internal, such as the buccal and lingual walls of the proximal box of a proximo-occlusal inlay (Fig 9-2, A). An intracoronal restoration resists displacement by wedge retention (Fig 9-2, B). Many restorations are a combination of the two types.

Taper

Because a cast metal or ceramic restoration is placed on or in the preparation after the restoration has been fabricated in its final form, the axial walls of the preparation must *taper* slightly to permit the restoration to seat; ie, two opposing external walls must gradually converge or two opposing internal surfaces of tooth structure must diverge occlusally. The terms *angle of convergence* and *angle of divergence* can be used to describe the respective relationships between the two opposing walls of a preparation.

The relationship of one wall of a preparation to the long axis of that preparation is the *inclination* of that wall. A tapered diamond or bur will impart an inclination of 2 to 3 degrees to any surface it cuts if the shank of the instrument is held parallel to the intended path of insertion of the preparation. Two opposing surfaces, each with a 3-degree inclination, would give the preparation a 6-degree taper.

Theoretically, the more nearly parallel the opposing walls of a preparation, the greater should be the retention. The most retentive preparation should be one with

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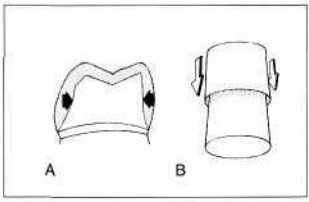


Fig 9-1 An extracoronal restoration (A) uses opposing external surfaces for retention (B).

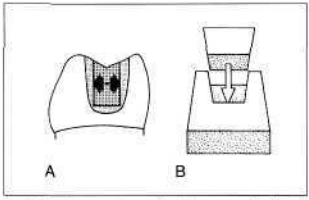


Fig 9-2 An intracoronal restoration (A) uses opposing internal surfaces for retention (B).

parallel walls. Indeed, parallel walls were advocated by some early authors.^ However, parallel walls are impossible to create in the mouth without producing preparation undercuts. Preparation walls are tapered to visualize preparation walls, prevent undercuts, compensate for inaccuracies in the fabrication process, and permit more nearly complete seating of restorations during cementation.

Ward was one of the first to recommend taper as such, prescribing 5% to 20% per inch (3 to 12 degrees, respectively).[3] Jorgensen[4] and Kaufman et al[5] have demonstrated experimentally that retention decreases as taper is increased (Fig 9-3). In recent years, recommendations for optimum axial wall taper of tooth preparations for cast restorations have ranged from 3 to 5 degrees,[6] 6 degrees,[7] and 10 to 14 degrees.[8] To minimize stress in the cement interface between the preparation and restoration, a taper of 2.5 to 6.5 degrees has been suggested as optimum, but there is only a slight increase in stress as taper is increased from 0 to 15 degrees.[9] However, at 20 degrees, stress concentration was found to increase sharply.

Studies of actual crown preparations have shown average tapers that have been much greater than the values recommended. Ohm and Silness reported mean tapers of 19.2 degrees mesiodistally and 23.0 degrees faciolingually on vital teeth, and 12.8 degrees mesiodistally and 22.5 degrees faciolingually on nonvital teeth.[10] Mack found an average clinical taper of 16.5 degrees." Weed et al found that dental students could produce full veneer crown preparations with a taper of 12 7 degrees on typodonts, but their clinical preparations had a mean taper of 22.8 degrees.'* Noonan and Goldfogel, surveying 909 student-prepared full gold crown preparations, reported an overall mean taper of 19.2 degrees.[13] On proficiency examinations, preparation tapers were decreased by 20%. Dies taken at random from commercial laboratories by Eames et al were found to have an average overall taper of 20 degrees.[14]

Kent and associates evaluated the degree of taper of 418 preparations, cut over 12 years by one operator[15] They found a mean of 15.8 degrees between mesial and distal walls and 13 4 degrees between facial and lingual walls for preparations in all areas of the mouth, with an overall mean of 14.3 degrees. The lowest combined taper (9.2 degrees) was seen on 145 anterior metal-ceramic crown preparations, while the greatest (22.2 degrees) was measured on 88 mandibular full crowns. Nordlander et al, analyzing 208 preparations done by 10 dentists, reported a low of 17.3 degrees for premolars and a high of 27.3 degrees for molars, with an overall mean of 19 9 degrees.[16]

Tooth preparation taper should be kept minimal because of its adverse effect on retention, but Mack estimates that a minimum taper of 12 degrees is necessary just to insure the absence of undercuts.[11] The tendency to overtaper preparations is one that must be guarded against constantly in order to produce preparations with the least possible taper and the greatest possible retention. Consciously attempting to cut a taper can easily result in an overtapered and nonretentive preparation. A taper or total convergence of 16 degrees has been proposed as being achievable clinically while still affording adequate retention.[11].^ This is probably an acceptable overall target. It can be as low as 10 degrees on preparations on anterior teeth and as high as 22 degrees on molars (Fig 9-4). Recommendations for degree of taper for specific teeth are given in Table 9-1.

Cement creates a weak bond, largely by mechanical interlocks, between the inner surface of the restoration and the axial wall of the preparation. Therefore, the greater the surface area of a preparation, the greater its retention.^[11] Simply stated, preparations on large teeth are more retentive than preparations on small teeth (Fig 9-5). This is a factor that must be considered when a preparation is done on a small tooth, especially when it is an abutment for a fixed partial denture or a splint. Surface area can be increased somewhat by adding boxes and grooves. However, the benefits derived from such features may relate more to their limiting the freedom of movement than to the increase in surface area.

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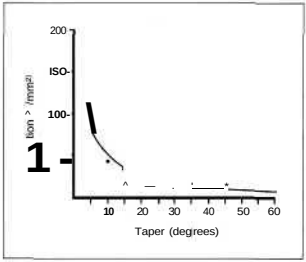


Fig 9-3 There is a relationship between taper and retention: as taper increases, retention decreases (after Jorgensen[4]).

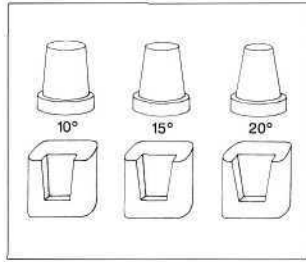


Fig 9-4 External *(top row)* and internal *(bottom row)* opposing surfaces demonstrate tapers of 10, 15, and 20 degrees.

Table 9-1 ***Optimum Degree of Tooth Preparation Taper***

Arch	M/D	F/L	Overall
Maxillary			
Anterior tooth*	10	10	10
Premolar*	14	14	14
Molar*	17	21	19
Isthmus†	—	—	7
Box†	—	—	7
Mandibular			
Anterior tooth*	10	10	10
Premolar*	16	12	14
Molar*	24	20	22
Isthmus†	—	—	12
Box†	—	—	12

*Convergence angle.
†Divergence angle.
M/D = mesiodistal; F/L = faciolingual.

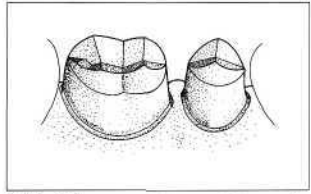


Fig 9-5 A full crown preparation is more retentive on a molar than on a premolar, because the molar preparation has greater surface area.

Freedom of Displacement

Retention is improved by geometrically limiting the numbers of paths along which a restoration can be removed from the tooth preparation.[20] Maximum retention is achieved when there is only one path. A full veneer preparation with long, parallel axial walls and grooves would produce such retention (Fig 9-6, A). On the opposite extreme, a short, overtapered preparation would be without retention because the restoration could be removed along an infinite number of paths (Fig 9-6, B). The best preparation, then, is one that approaches the ideal and can be achieved within the limits of operator skill, accessibility, and laboratory technology.

Limiting the freedom of displacement from torquing or twisting forces in a horizontal plane increases the resistance of a restoration. A groove whose walls meet the axial wall at an oblique angle does not provide the necessary resistance (Fig 9-7, A). V-shaped grooves produce roughly one-half as much resistance to lingual displacement as do grooves with a definite lingual wall.[21] Forces that produce rotating movement in the restoration can produce shear and eventual slippage along the surfaces oblique to the direction of the force. There must be a definite wall perpendicular to the direction of the force to sufficiently limit the freedom of displacement and provide adequate resistance (Fig 9-7, B).

A proximal box must be treated in a similar manner. If

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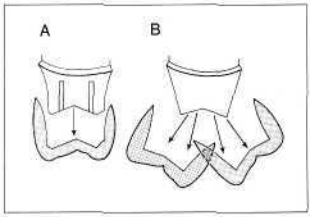


Fig 9-6 By limiting the paths of withdrawal, retention is improved (A). A preparation with unlimited freedom of displacement is much less retentive (B).

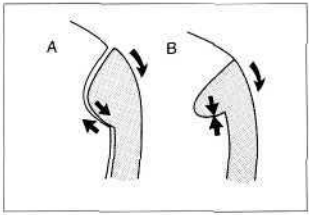


Fig 9-7 •flie walls of a groove that meet the axial wall at an oblique angle do not provide necessary resistance (A); trie walls of a groove must be perpendicular to rotating forces to resist displacement (B).

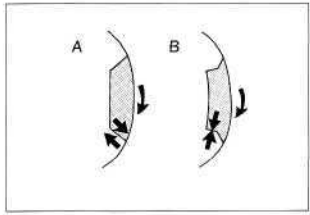


Fig 9-8 The buccal and lingual walls of a box will nut resist rotational displacement if they form oblique angles with the pulpal wall (A); they must meet the pulpal wall at angles near 90 degrees (B).

its buccal and lingual walls form oblique angles with its pulpal wall, there will not be adequate resistance to rotating forces (Fig 9-8, A). The buccal and lingual walls must meet the pulpal wall at angles near 90 degrees so that these walls will be perpendicular to any forces which would tend to rotate the restoration (Fig 9-8, B). A flare is then added to the box so that there can be an acute edge of gold at the cavosurface margin of the restoration.

Length

Occlusogingival length is an important factor in both retention and resistance. Longer preparations will have more surface area and will therefore be more retentive. Because the axial wall occlusal to the finish line interferes with displacement, the length and inclination of that wall become factors in resistance to tipping forces.

For the restoration to succeed, the length must be great enough to interfere with the arc of the casting pivoting about a point on the margin on the opposite side of the restoration (Fig 9-9, A).[22] The shorter wall does not afford this resistance (Fig 9-9, B). The shorter the wall, the more important its inclination. The walls of shorter preparations should have as little taper as possible to increase the resistance. Even this will no! help if the walls are too short.

It may be possible to successfully restore a tooth with short walls if the tooth has a small diameter. The preparation on the smaller tooth will have a short rotational radius for the arc of displacement, and the incisal portion of the axial wall will resist displacement (Fig 9-10, A). The longer rotational radius on the larger preparation allows for a

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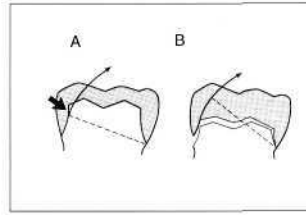


Fig 9-9 The preparation with longer walls (A) interferes with the tipping displacement of the restoration better than the short preparation (B).

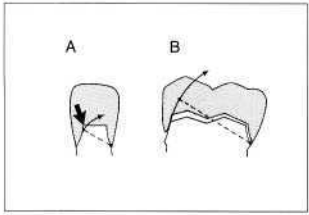


Fig 9-10 A preparation on a tooth with a smaller diameter (A) resists pivoting movements better than a preparation of equal length on a tooth of larger diameter (B).

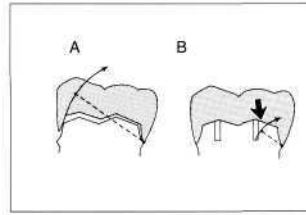


Fig 9-11 The resistance of a short preparation (A) can be improved by adding grooves (B).

more gradual arc of displacement, and the axial wall does not resist removal (Fig 9-10, B). Parker et al found that approximately 95% of anterior preparations analyzed had resistance form, while only 46% of those on molars did.[73]

Resistance to displacement for a short-walled preparation on a large tooth can be improved by placing grooves in the axial walls. In effect, this reduces the rotational radius, and that portion of the walls of the grooves near the occlusal surface of the preparation will interfere with displacement (Fig 9-11).

Substitution of Internal Features

The basic unit of retention for a cemented restoration is two opposing axial walls with a minimal taper. It may not always be possible to use opposing walls for retention: one may have been destroyed previously, or it may be desirable to leave a surface uncovered for a partial veneer restoration. It may also be that the walls are present, but with a greater than desirable inclination. Generally, internal features such as the groove, the box form, and the pin hole are interchangeable and can be substituted for an axial wall or for each other (Fig 9-12). Substitution is important, since conditions often preclude making an ideal preparation.

Kent et al reported a marked difference between the degree of taper of full crown preparations (18.4 to 22.2 degrees) and that of boxes and grooves in the axial surfaces of those preparations (7.3 degrees).[15] The taper of these internal features is nearly the same as the taper of the the instruments used to cut them (4 to 6 degrees). Apparently the widely separated axial walls of the prepa-

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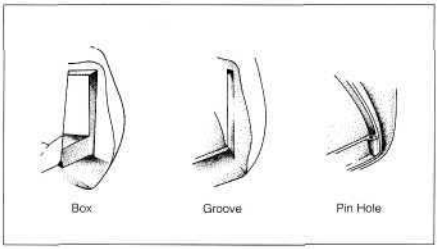


Fig 9-12 These preparation features ate frequently substituted for each other.

rations are overinclined because of access, visibility, or bolh. In preparing an internal feature such as a groove or a box, however, the much shorter distance between the walls allows the dentist to prepare them more precisely. These features offer an excellent means of enhancing lhe overall retention and resistance of an otherwise over-inclined axial wall. Woolsey and Matich found that proximal grooves on short 15-degree dies provide complete resistance to faciolingual horizontal displacement.[24]

Path of Insertion

The *path olinsertion* is an imaginary line along which the restoration will be placed onto or removed from the preparation. It is determined mentally by the dentist before the preparation is begun, and all features of the preparation are cut to coincide with that line. The path of insertion is not arbitrarily set at the completion of the preparation by adding some feature, such as grooves. It is of special importance when preparing teeth to be fixed partial denture abutments, since the paths of all the abutment preparations must parallel each other.

The correct technique must be used to survey a preparation visually, since this is the primary means of insuring that the preparation is neither undercut nor over-tapered. If the center of the occlusal surface of a preparation is viewed with one eye from a distance of approximately 30 cm (12 inches), it is possible to sigh! down the axial walls of a preparation with a minimum taper (Fig 9-13). However, it is possible to sight down the axial walls of a preparation with a reverse (ie, undercut) taper of 8 degrees when both eyes are open (Fig 9-14). This occurs because of the distance between the eyes, which is responsible for binocular vision. Therefore, it is important that preparations be viewed with one eye closed.

For a preparation to be surveyed in the mouth, where direct vision is rarely possible, a mouth mirror is used (Fig 9-15). It is held at an angle approximately 1/2 inch above the preparation, and the image is viewed with one eye. If fixed partial denture abutment preparations are being evaluated for a common path of insertion, a firm finger rest is established and the mirror is maneuvered until one preparation is centered. Then, pivoting on the finger rest, the mirror is moved, without changing its angulation, until it is centered over the second preparation

The path of insertion must be considered in two dimensions: faciolingualty and mesiodistally. The facio-lingual orientation of the path can affect the esthetics of metal-ceramic or partial veneer crowns. For metal-ceramic crowns, the path is roughly parallel with the long axis of the teeth (Fig 9-16). A facially inclined path of insertion on a preparation for a metal-ceramic crown will leave the facio-occlusal angle too prominent, resulting in overcontouring of the restoration, "opaque show-through," or both.

Leaning the path to the facial will force the overcutting of the mesiofacio-occlusal corner of a three-quarter crown preparation, leading to an unnecessary display of gold. For three-quarter crowns on anterior teeth, the path of insertion should parallel the incisal one-half of the labial surface (Fig 9-17). If it is inclined more facially, short grooves and an unnecessary display of gold will result.

The mesiodistal inclination of the path must parallel the contact areas of adjacent teeth. If the path is inclined mesially or distally, the restoration will be held up at the proximal contact areas and be "locked out" (Fig 9-18). This is a particular problem when restoring a tilted tooth. In this situation, making the path of insertion parallel with the long axis of the tooth will cause the contacts of the adjacent teeth to encroach on the path of insertion

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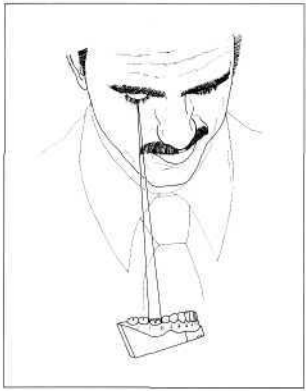


Fig 9-13 To examine a preparation for undercuts, one eye should be closed.

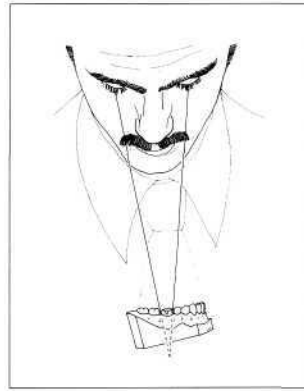


Fig 9-14 If both eyes are open when the preparation is viewed, undercuts may remain undetected.

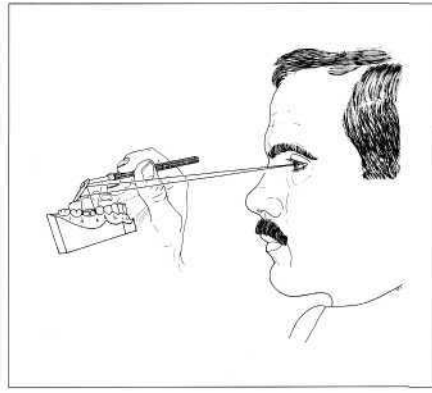


Fig 9-15 Preparations in the mouth are viewed through a mouth mirror using one eye.

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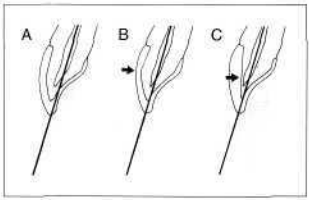


Fig 9-16 The path of insertion of a preparation for a metal-ceramic crown should parallel the long axis of the tooth (A). If the path is directed facially, the prominent facioincisal angle may create esthetic problems of overcontouring or "opaque show-through" (B). However, if the path is directed lingually, the facial surface will intersect the lingual surface, creating a shorter preparation. It also may encroach on the pulp (C),

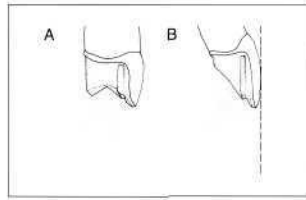


Fig 9-17 The path of insertion of a three-quarter crown on a posterior tooth parallels the long axis of the tooth (A), while it parallels the incisal one-half to two-thirds of the labial surface of an anterior tooth (B).

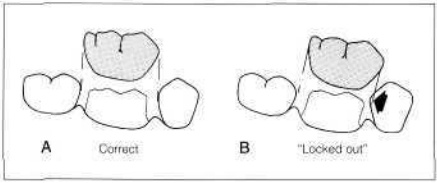


Fig 9-18 The path of insertion of a preparation must parallel the adjacent proximal contacts (A), or it will be prevented from seating (B).

Structural Durability

A restoration must contain a bulk of material that is adequate to withstand the forces of occlusion. This bulk must be confined to the space created by the tooth preparation. Only in this way can the occlusion on the restoration be harmonious and the axial contours normal, preventing periodontal problems around the restoration.

Occlusal Reduction

One of the most important features for providing adequate bulk of metal and strength to the restoration is occlusal clearance (Fig 9-19). For gold alloys, there should be 1.5 mm of clearance on the functional cusps (lingual of maxillary molars and premolars and buccal of mandibular molars and premolars). Not quite as much is required on the nonfunctional cusp, where 1.0 mm is sufficient.

Metal-ceramic crowns will require 1.5 to 2.0 mm on functional cusps that will be veneered with porcelain and 1.0 to 1.5 mm on nonfunctional cusps to receive ceramic coverage. There should be 2.0 mm of clearance on preparations for all-ceramic crowns. Malposed teeth may have occlusal surfaces that are not parallel with the occlusal table. Therefore, it may not be necessary to reduce the occlusal surface by 1.0 mm to achieve 1.0 mm of clearance.

The basic inclined plane pattern of the occlusal surface should be duplicated to produce adequate clearance without overshortening the preparation (Fig 9-20). A flat occlusal surface may overshorten a preparation whose length is already minimal to provide adequate retention. Inadequate clearance makes a restoration weaker. In addition, inadequate reduction under the anatomic grooves of the occlusal surface will not provide adequate space to allow good functional morphology. The restoration also will be much more easily perforated by finishing procedures or by wear in the mouth.

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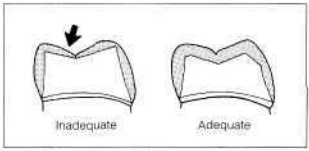


Fig 9-19 Inadequate occlusal reduction does not provide the needed space for a cast restoration of adequate thickness.

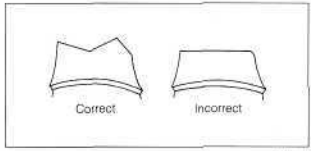


Fig 9-20 Occlusal reduction should reproduce basic inclined planes rather than being cut as one flat plane.

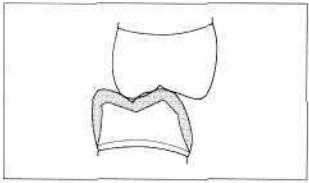


Fig 9-21 The functional cusp bevel is an integral part of occlusal reduction.

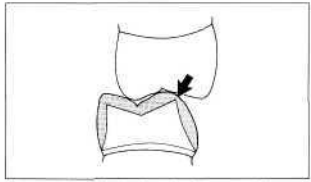


Fig 9-22 Lack of a functional cusp bevel can cause a thin area or perforation in the casting.

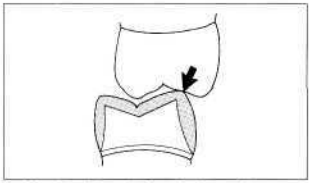


Fig 9-23 Lack of a functional cusp bevel may result in overcontouring and poor occlusion.

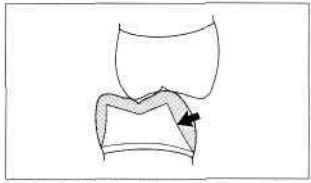


Fig 9-24 Overinclination of the buccal surface will destroy excessive tooth structure while lessening retention.

Functional Cusp Bevel

An integral part of the occlusal reduction is the functional cusp bevel (Fig 9-21). A wide bevel on the lingual inclines of the maxillary lingual cusps and the buccal inclines of mandibular buccal cusps provides space for an adequate bulk of metal in an area of heavy occlusal contact.

If a wide bevel is not placed on the functional cusp, several problems may occur. If the crown is waxed and cast to normal contour, the casting will be extremely thin in the area overlying the junction between the occlusal and axial reduction (Fig 9-22). To prevent a thin casting when there is no functional cusp bevel, an attempt may be made to wax the crown to optimal thickness in this area. An overcontoured restoration will result and a deflective occlusal contact is likely to occur unless the opposing tooth is reduced (Fig 9-23).

If an attempt is made to obtain space for an adequate bulk in a normally contoured casting without a bevel, the result will be an overcut axial surface (Fig 9-24). In addition to the unnecessary destruction of tooth structure, the severe inclination of the surface renders it useless for retention.

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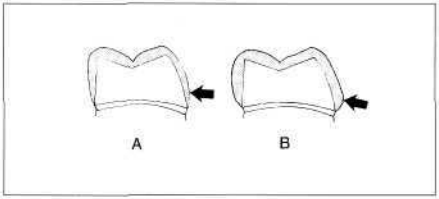


Fig 9-25 Inadequate axial reduction can cause thin walls and a weak restoratlon (A) or a bulbous, overcontoured restoration (Bi.

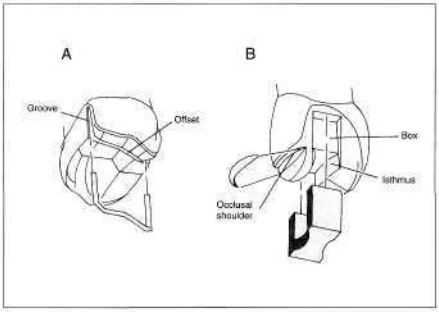


Fig 9-26 The three-quarter crown is reinforced by the bulk of gold that fills the offset and grooves (A). The occlusal shoulder strengthens the lingual margin, and the isthmus and boxes reinforce the main body of an MOD onlay (B).

Axial Reduction

Axial reduction also plays an important role in securing space for an adequate thickness of restorative material (Fig 9-25). If restorations are made with normal contours over preparations with inadequate axial reduction, they will have thin walls that will be subject to distortion. Frequently laboratory technicians attempt to compensate for this by overcontouring the axial surfaces. While this "solution" to the problem strengthens the restoration, it can have a disastrous effect on the periodontium.

There are other features that serve to provide space for metal that will improve the rigidity and durability of the restoration: the offset, the occlusal shoulder, the isthmus, the proximal groove, and the box (Fig 9-26). The isthmus connects the boxes, and the offset ties the grooves together to enhance the reinforcing "truss effect."^

Marginal Integrity

The restoration can survive in the biological environment of the oral cavity only if the margins are closely adapted to the cavosurface finish line of the preparation. The configuration of the preparation finish line dictates the shape and bulk of restorative material in the margin of the restoration. It also can affect both marginal adaptation and the degree of seating of the restoration.

To Bevel, or . . .

Cast metal restorations can be made to fit preparations with a high degree of precision, but even in well-fitting

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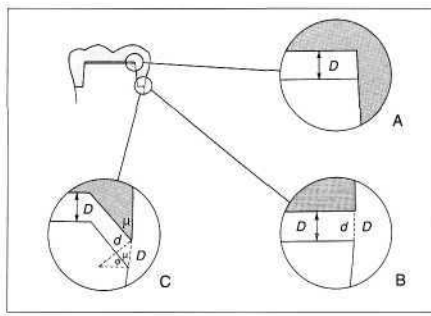


Fig 9-27 Any failure of the restoration to seal (D in inset A) is reflected as a marginal opening of the same dimension on a shoulder perpendicular to the path of insertion (B). As the angle of the margin (ji) approximates 0 degrees (O, the distance between the margin and the tooth *(d)* approaches 0, based on the assumption that the gap can be closed completely (after Rosner[45]).

castings there is some discrepancy between the margin of the restoration and the preparation. Bevels have been advocated as a means of diminishing marginal discrepancy,[55] If the vertical discrepancy in fit is designated as *D,* the distance between the restoration and preparation (Fig 9-27, A) occurs unchanged between the margin, *M,* and the finish line, P (Fig 9-27, B). However, the closest distance between the margin and the surface of the preparation is a line, *d,* that is perpendicular to the surface of the tooth (Fig 9-27, C). It can be stated as a function of *D* and the sine of angle \&, or the cosine of angle *ty:*

$$d = D \sin \mu \quad (1)$$

or

$$d = D \cos \phi \quad (2)$$

As angle ji becomes smaller (more acute), the sine of u. becomes smaller (Table 9-2); or as angle § becomes larger (more obtuse), the cosine of ϕ becomes smaller. By either computation, *d* diminishes by the same amount. The more acute the angle of the margin, \i, or the more obtuse the angle of the finish line, ϕ, the shorter the distance between the restoration margin and the tooth. This argument is based on the premise that the distance between the margin and tooth structure is infinitely closeable, and as long as there is no cement between the restoration and the preparation, that is true.

Table 9-2 ***Trigonometric Functions of Angles Oto 90 Degrees***

Angle (degrees)	Sine	Cosine
0	0	1.000
15	0.259	0.966
30	0.500	0.866
45	0.707	0.707
60	0.866	0.500
75	0.966	0.259
90	1.000	0

. . . Not to Bevel

However, as shown so convincingly by Ostlund.^ the presence of cement changes the scenario completely. The film thickness of the cement will prevent the complete seating of a casting with bevels that are nearly parallel with the path of insertion of the restoration, just as Jorgensen,[4] Kaufman et al.,[11] and Eames and associates[14] found that crowns did not seat completely on dies with minimal taper.

The film thickness of the cement imposes a limit on the reduction of the perpendicular distance from the margin to the tooth, *d.* The distance, *d,* therefore becomes a constant, and the previous equation is solved for *D* instead of *d:*

$$D = d / \sin \mu. \quad (3)$$

or

$$D = d / \cos \phi \quad (4)$$

As the angle of the margin bevel becomes more acute, its sine becomes smaller, and as the angle of the finish line becomes more obtuse, its cosine becomes smaller, and *D* becomes larger The more nearly the bevel parallels the path of insertion, the greater the distance by which the restoration fails to seat (Fig 9-28)

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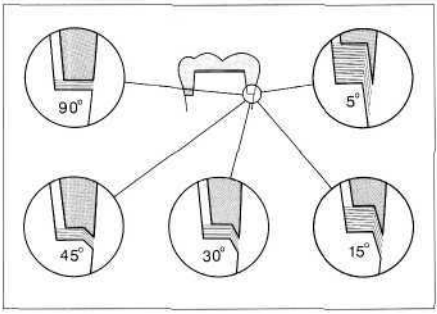


Fig 9-28 The cement film thickness prevents complete closure of the gingival gap. If a bevel of 45 degrees is addedto a shoulder, the crown"will be prevented from seating by a factor of 1.4. However, as the margin is decreased to an angle of 30 degrees, [he crown is displaced twice as much as it would be with a shoulder. Margins of 15 and 5 degrees would prevent seating by factors of 3.9 and 11.5, respectively. If the marginal gap for the shoulder were 25 Um, the ADA specification for cement film thickness, the addition of a 5 degree bevel could keep the casting from seating by nearly 0.3 mm. All pa'es in the insets are drawn to scale.

McLean and Wilson have disputed the use of bevels for metal-ceramic crowns because the bevel margin must be 10 to 20 degrees to noticeably improve adaptation.[28] The finish line must also be placed too far subgingivally to hide the resultant metal collar. Pascoe demonstrated that slightly oversized castings with shoulders exhibit the least marginal discrepancy.[29] Gavelis et al found a better marginal seal with acute-edged margins, but they found that shoulders permitted the most complete seating of a crown.[30] Panno and associates reported no better adaptability of crowns with highly acute 80-degree bevels than those with less acute 45-degree bevels.[31]

Empirical clinical results dictate that the acute angle margin should continue to be used on metal restorations but that the angle should be in the 30- to 45-degree range. The tapered edge in a wax pattern margin produced by a bevel is more readily adapted to a die than is a butt joint, and a gold margin can be burnished to slightly improve its adaptation after casting.

Finish Line Configurations

Wide, shallow bevels that are nearly parallel with the outer surface of the tooth should be avoided. They are likely to lead to overcontouring. Even if the axial surfaces of the overlying crown are not overcontoured, the resultant thin, unsupported wax at the margin potentially will break or distort when the wax pattern is withdrawn from the die and invested. The optimum margin for a gold alloy casting is an acute edge with a nearby bulk of metal.

The preferred gingival finish line for veneer metal restorations is the *chamfer* (Fig 9-29). This tinish line has been shown experimentally to exhibit the least stress, so that the cement underlying it will have less likelihood of failure.[3A33] It can be cut with the tip of a round-end diamond, while the axial reduction is being done with the side of that instrument. However, a torpedo diamond is less likely to produce a butt joint. The margin of the cast restoration that fits against it combines an acute edge with a nearby bulk of metal.

A *heavy chamfer* is used to provide a 90-degree cavosurface angle with a large-radius rounded internal angle (Fig 9-30). It is created with a round-end tapered diamond. In the hands of an unskilled operator, this instrument can create an undesirable fragile "lip" of enamel at the cavosurface. The heavy chamfer provides better support for a ceramic crown than does a conventional chamfer, but it is not as good as a shoulder. A bevel can be added to the heavy chamfer for use with a metal restoration.

The *shoulderhas* long been the finish line of choice for the all-ceramic crown (Fig 9-31). The wide ledge provides resistance to occlusal forces and minimizes stresses that might lead to fracture of the porcelain. It produces the space for healthy restoration contours and maximum esthetics. However, it does require the destruction of more tooth structure than any other finish line. The sharp, 90-degree internal line angle associated with the classic variety of this finish line concentrates stress in the tooth and is conducive to coronal fracture. The shoulder generally is noi used as a finish line for cast metal restorations.

The *radial shoulder* is a modified form of shoulder finish line (Fig 9-32). The initial instrumentation of the ledge is accomplished with the same flat-end tapered diamond

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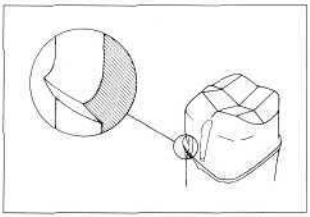


Fig 9-29 Chamfer finish line demonstrated on a full veneer crown preparation.

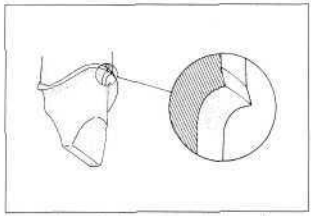


Fig 9-30 Heavy chamfer on a preparation for an all-ceramic crown.

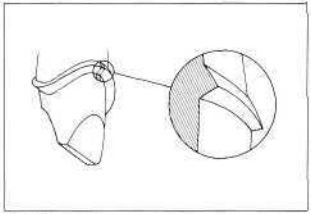


Fig 9-31 Shoulder on a preparation for an all-ceramic crown (a traditional porcelain jacket crown).

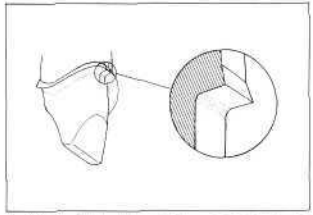


Fig 9-32 A radial shoulder on an all-ceramic crown preparation combines maximum support of the ceramic with a stress-reducing, rounded gingivoaxial "angle."

used for the classic shoulder A small-radius rounded internal angle is instrumented by an end-culting parallel-sided carbide finishing bur, and finishing is completed with a specially modified bin-angle chisel. The cavosurface angle is 90 degrees, and shoulder width is only slightly lessened by the rounded internal angle. Stress concentration is less in the tooth structure than with a classic shoulder, and support for ceramic restoration walls is good. Destruction of tooth structure required for this configuration is not significantly less than that required for a classic shoulder, however.

The *shoulder with a bevel* is used as a finish line in a variety of situations (Fig 9-33). It is utilized as the gingival finish line on the proximal box of inlays and onlays, and for the occlusal shoulder of onlays and mandibular three-quarter crowns. This design can also be used for the facial finish line of metal-ceramic restorations where gingival esthetics are not critical. It can be used in those situations where a shoulder is already present, either because of destruction by caries or the presence of previous restorations. It is also a good finish line for preparations with extremely short walls, since it facilitates axial walls that are nearly parallel.[3-1]

By adding a bevel to an existing shoulder, it is possible to create an acute edge of metal at the margin. The shoulder with a bevel should not be used routinely for full

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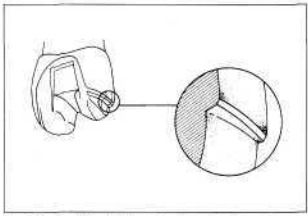


Fig 9-33 Shoulder with a bevel on the occlusal shoulder of an MOD onlay.

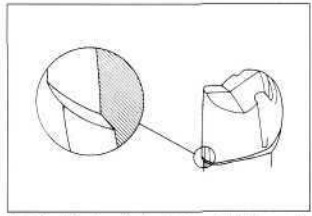


Fig 9-34 Knife edge on the lingual of a mandibular three-quarter crown.

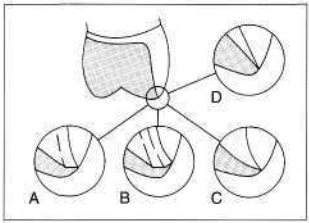


Fig 9-35 Bucco-occlusal finish lines or a maxillary three-quarter crown. A flat bevel (A), a contrabevel (B), and, when the cusp is bulky, a knife edge (C), are acceptable finish lines. The knife edge is not an acceptable finish line on small, sharp cusps (D). (After Ingraham et al[35] and Richter and Veno.[51])

veneer restorations because the axial reduction required to obtain it is unnecessarily destructive of tooth structure. Some variation of a shoulder, with or without a bevel, may afford some resistance against distortion during porcelain firing.[35]

The ultimate in finish lines that permit an acute margin of metal is the *knife edge* (Fig 9-34). Unfortunately, its use can create problems. Unless it is carefully cut, the axial reduction may fade out instead of terminating in a definite finish line. The thin margin of the restoration that fits this finish line may be difficult to accurately wax and cast. It is also more susceptible to distortion in the mouth when the casting is subjected to occlusal forces.

The use of the knife edge can result in overcontoured restorations when an attempt is made to obtain adequate bulk by adding to the external axial contours of the restoration. In spite of its drawbacks, it is sometimes necessary to use the knife edge. It may have to be used on the lingual surface of mandibular posterior teeth, on teeth with very convex axial surfaces, and on the surface toward which a tooth may have tilted.

The finish line used for the bucco-occlusal margin of maxillary partial veneer and MOD onlay restorations is worthy of attention. It too must meet the requirement of providing an acute edge with a nearby bulk of metal. The enamel must also be protected by a finishing bevel that will leave the tooth structure at the cavosurface angle with sufficient bulk to resist fracture and chipping.[36] The most commonly used form is a narrow (0.3 to 0.5 mm) finishing bevel perpendicular to the path of insertion of the restoration (Fig 9-35, A). A contrabevel may also be used where function is heavy and esthetic requirements are minimal (Fig 9-35, B). There are a few situations in which no bevel is required (Fig 9-35, C), but this can only be accomplished on a cusp that is bulky enough to allow the acute edge of metal and still be able to finish the enamel at the cavosurface angle. A bevel is mandatory if its elimination will create an unsupported edge of enamel (Fig 9-35, D).

Preservation of the Periodontium

The placement of finish lines has a direct bearing on the ease of fabricating a restoration and on the ultimate success of the restoration. The best results can be expected from margins that are as smooth as possible and are fully exposed to a cleansing action.[37] Whenever possible, the finish line should be placed in an area where the margins of the restoration can be finished by the dentist and kept clean by the patient. In addition, finish lines must be placed so that they can be duplicated by the impression, without tearing or deforming the impression when it is removed past them.

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Finish lines should be placed in enamel when it is possible to do so. In the past, the traditional concept has been to place margins as far subgingivally as possible, based on the mistaken concept that the subgingival sulcus is caries-(ree.[3a] The practice of routinely placing margins subgingivally is no longer acceptable. Subgingival restorations have been described as a major etiologic factor in periodontitis.[39-44] The deeper the restoration margin resides in the gingival sulcus, the greater the inflammatory response.[47-50]

Although Richter and Ueno reported no difference between subgingival and supragingival margins in a 3-year clinical study, they recommended that placement be supragingival whenever possible.[51] Eissmann et al made a similar recommendation.[37] Koth also failed to find a link between margin location and gingival health in a selected patient population on a strict hygiene regimen.[52]

These studies do not refute the evidence that subgingival margins are likely to cause gingival inflammation. They merely demonstrate that margin location is not as crucial when placed by a highly skilled dentist in the mouth of a motivated, cooperative patient. Ego may tempt a dentist to believe that he or she is one of the "good guys" who can handle the "simple" task of achieving well-fitting albeit subgingival margins on a crown. However, subgingival margins can be very difficult to evaluate.

Christensen demonstrated that experienced restorative dentists can miss marginal defects as great as 120]im when the margins are subgingival.[53] In a radiographic study, Bjorn et al found that more than half of the proximal margins of gold crowns had defects greater than 0.2 mm and more than 40% of the proximal margins of ceramic crowns had defects thai exceeded 0.3 mm.[54]

Nonetheless, there will be many situations in which subgingival margins are unavoidable. Because preparation length is such an important factor in resistance and retention, preparations are frequently extended subgingivally to increase retention.-ts-ss-se The placement of finish lines can also be altered from ideal locations by caries,[45-55-58] the extensions of previous restorations,[45-55-57] trauma,[45-57] or esthetics.[45-Ku-Sfi]

Exercise caution if conditions require that the finish line be placed any closer to the alveolar crest than 2.0 mm, which is the combined dimension of the epithelial and connective tissue attachments.[59] Placement of a restoration margin in this area probably will result in gingival inflammation, loss of alveolar crest height, and formation of a periodontal pocket.[60] "Crown lengthening" may be done to surgically move the alveolar crest 3.0 mm apical to the location of the proposed finish line to guarantee the biologic width and prevent periodontal pathology. This will allow space for the connective and epithelial attachments and a healthy gingival sulcus. If the deep finish line is located interproximally and will require extensive removal of bone between the tooth being restored and the adjacent tooth, it may be better to extract the tooth in question rather than periodontally compromise its healthy neighbor.

Instrumentation

The preparation of teeth to receive cast metal or ceramic restorations does not require an extensive armamentarium (Table 9-3). The excavation of caries should be accomplished with sharp spoon excavators and round burs (no. 4 or no. 6) mounted in a contra-angle handpiece. Hand chisels may be used to accentuate the facial and lingual walls of proximal boxes. All other procedures usually are accomplished with a high-speed air turbine handpiece.

Small diamond points, used with a water-air spray in a high-speed handpiece, will remove precisely controlled amounts of tooth structure. The surface that remains can be easily smoothed. There is no indication for the use of large diamond cutting discs in low-speed contra-angle or straight handpieces. They frequently overextend preparations, and their potential for injury to the patient is great.

It is important that the cavosurface finish line be smooth and continuous to facilitate the fabrication of restorations with well-adapted margins. Gross reduction is most efficiently accomplished with coarse diamonds. However, they leave irregular cavosurface finish lines,[61-62] and some other instrument should be used to obtain a smooth finish line By using diamonds and carbide finishing burs of the same size and shape, as developed by Lustig et al,[63-64] it is possible to maintain the finish line configuration developed by the diamond instrument Torpedo diamonds are followed by torpedo carbide burs to produce chamfers; flat-end tapered diamonds by H158 carbide finishing burs for radial shoulders; and flame diamonds *by* flame burs for gingival bevels and conservative proximal flares. Acceptable finish lines on vertical flares can be obtained by the use of abrasive paper discs,[6i] but they should be used with a rubber dam to protect soft tissue.

Nondentate tapered burs (169L, 170L, and 171L) are used for grooves, boxes, isthmuses, and offsets where they are needed. They are also used for smoothing any surface that will not terminate in a curved finish line, which they would nick, and for creating occlusal and incisal bevels Cross-cut or dentate burs are employed for removal of old restorations, but the horizontal ridges they leave on tooth structure make them unacceptable for planing tooth surfaces

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Table 9-3 *Rotary Instruments for Tooth Preparations*

Shape	Use	Manufacturer										
		Brasseler	Busch	Dritisco	Horico	Midwest	Miltex	Premier	SS White	Star	Union	Vaitage
Round-end tapered diamond	1. Depth orientation grooves 2. Occlusal reduction 3. Functional cusp	856-016	—	775	199-016	198-016	—	770 8	854-016	770-8	D-18	850/018
Flat-end tapered diamond	1. Axial reduction (MCR, PJC) 2. Shoulder (MCR, PJC)	847-016	—	770	172-016	172-018	—	701.7	847-016	700-7	117	848/018
Torpedo diamond	1. Axial reduction 2. Chamfer finish line	877-010	–	232	138-012	289-012	—	251.8	884-012	250-7 ½	124	884/012
Short needle	1. Initial proximal axial reduction (posterior teeth)	852-012	—	715	164-012	161 016	—	209.6	845-010	769-5	D11	849/010
Long needle	1. Initial proximal axial reduction (anterior teeth)	30006-012	—	703	167-011	161.021	—	700.9	852-011	769T-9	D3	852/011
Flami3 diamond	1. Proximal flare 2. Gingival bevel	862-010	—	216	249-010	249-012	—	260.8	852-012	260-8	205L	862/012
Smal1 wheel diamond	LingLjal reduction (anterior teeth)	909-040	—	825	068-040	068-040	—	863	909-035	110	11A	909/035
Tapered fissure bur	1. Seating groove 2. Proximaf groove (posterior teeth) 3. Offset 4. Occlusal shoulder 5. Isthmus 6. Proximal box 7. Smoothing and finishing 8. Occlusal and mcisal bevels	171L-012	171L-012	171L-012	—	171L-012	171L	71L-012	171L	—	171L-012	—
Tapered fissure burs	1. Initial groove alignment 2. Angles of proximal boxes 3. Smoothing and finishing 4. Occlusal and incisal bevels	170L-010 169L-009	170L-010 —	170L-010 169L-009	— —	170L-010 169L-009	170L 169L	70L-009 69L-008	170L 169L	— —	170L-010 169L-009	— —

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Table 9-3 *Continued*

Shape	Use	Manufacturer*										
		Brasseler	Busch	Densco	Horico	Midwest	Millex	Premier	SS White	Star	Union	Vantage
End cutting bur	1. Conventional shoulder finishing	957-010	957-010	957-010	—	—	957	—	957	–	957-010	–
Torpedo bur	1. Axial wall finishing 2. Chamfer finishing	282-010	243-010	–	—	—	—	—	—	—	—	—
Flame bur	1. Flare and bevel finishing	H48L-010	—	—	—	—	—	—	—	—	—	—
Radial fissure bur	1. Radial shoulder finishing	H158-012	—	—	—	—	—	—	—	—	—	—

•Brasseler USA Inc, Savannah, GA
Busch, Pfingsl 8 Co, Inc. South Plainfield, NJ
Densco, Teledyne Getz, Elk Grove Village, IL
Horico, Pfingst & Co, Inc, South Plainfield, NJ
Midwest Dental Products Corporation, Des Plaines, IL
Miltex Instrument Co, Inc, Lake Success, NY
Premier Dental Products Co, Norristown, PA
SS White Burs, Inc. Lakewood, NJ
Star Dental Products, Lancaster. PA
Union Broach Division of Moyco Industries, Emigsville, PA
Vantage, Miltex Instrument Co. Inc, Lake Success. NY

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Chapter 10

Preparations for Full Veneer Crowns

There are numerous situations that call for the use of a full veneer restoration. Clinicians have long considered it to be the most retentive of the veneer preparations.[1] Controlled laboratory studies have shown that when compared with partial veneer designs, the full veneer crown exhibits superior retention[2,3] and resistance.[4] This does not mean that a full veneer design must be used on every tooth. Instead, it should be used on those teeth whose restoration demands maximum retention.

A requirement for maximum retention is not commonly seen in the placement of single restorations. This need is more likely to be manifested in the design of retainers for fixed partial dentures, where additional demands are placed on the preparation and restoration. The selection of a full veneer crown retainer becomes mandatory when the abutment tooth is small or when the edentulous span is long.

Variations of the full veneer crown, the metal-ceramic crown or the all-ceramic crown, are used in situations that require a good cosmetic result. The full veneer crown should be used when less extensive and less destructive designs have been considered and found lacking in retention, resistance, coverage, or esthetics to properly restore the tooth.

Full coverage in the right circumstances can be excellent treatment, but it is overused. A report of dental insurance data in 1979 indicated that nearly 93% of the cast restorations done by dentists submitting claims to that company were of a full-coverage design.[6] Undoubtedly the percentage would be greater today. The removal of all morphologic form of the tooth is radical treatment, and restoring it properly can be difficult.[6] The dentist should be sure it is necessary.

Full Metal Crown Preparation

When all of the axial surfaces of a posterior tooth have been attacked by decalcification or caries, or when those surfaces have been previously restored, the tooth is a candidate for a full metal crown. By tying together the remaining tooth structure, a full metal crown can strengthen and support the tooth.[7] It should be used judiciously, though, because it does require a destructive preparation. It may weaken rather than strengthen the remaining tooth structure when there has been extensive destruction previously in the center of the tooth. However, the preparation for a full metal crown is less destructive than that required for either metal-ceramic or all-ceramic crowns.

Full coverage should not be used in mouths with uncontrolled caries. The full veneer crown is a restoration that replaces lost tooth structure and imparts some measure of structural support to the tooth. However, it does not protect the tooth against the biological causes of the caries. These processes must be controlled by other means before any restoration can be successful.

Armamentarium

1. Handpiece
2. No. 171l_bur
3. Round-end tapered diamond
4. Short needle diamond
5. Torpedo diamond
6. Torpedo bur
7. Red utility wax

The preparation for a full veneer crown is begun with occlusal reduction, creating about 1.5 mm of clearance on the functional cusps and 1.0 mm on the nonfunctional cusps. By accomplishing this step first, the occlusogingival length of the preparation can be determined. The potential retention of the preparation can then be assessed, and auxiliary features can be added if necessary.

Depth-orientation grooves are placed on the occlusal surface of the tooth to provide an easy reference to determine when reduction is sufficient. If reduction is begun without orientation marks, time will be wasted in repeated checks for adequate clearance. A round-end tapered diamond is used to place the grooves on the ridges and the primary grooves of the occlusal surface. If there is already some clearance with the opposing tooth because

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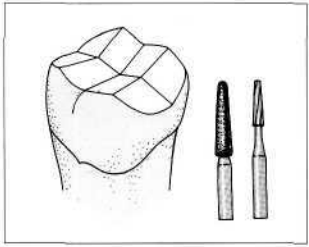


Fig 10-1 Occlusal reduction: Round-end tapered diamond and no. 171L bur.



Fig 10-2 Functional cusp bevel: Round-end tapered diamond and no. 171L bur.

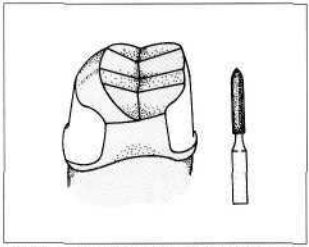


Fig 10-3 Buccal and lingual axial reduction: Torpedo diamond.

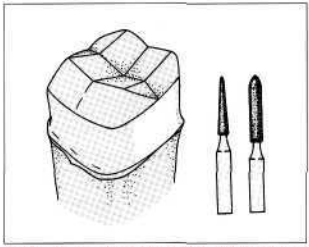


Fig 10-4 Proximal axial reduction: Short needle and torpedo diamonds.

of malpositioning or fracture of the tooth being prepared, the grooves should not be made as deep.

The tooth structure remaining between the orientation grooves is removed to accomplish the occlusal reduction (Fig 10-1). Any roughness left by the grooves should be removed, keeping the occlusal surface in the configuration of the geometric inclines that make up the occlusal surface of any posterior tooth.

A wide bevel is placed on the functional cusp, again using the round-end tapered diamond (Fig 10-2). Depth-orientation grooves are also helpful in obtaining this reduction. The functional cusp bevel, placed on the buccal inclines of mandibular buccal cusps and the lingual inclines of maxillary lingual cusps, is an integral part of the occlusal reduction. Failure to place this bevel can produce a thin casting or poor morphology in the restoration.

Occlusal clearance is checked by having the patient close on a 2.0-mm-thick strip of red utility wax held over the preparation. The wax is then held up to a light to determine the adequacy of the occlusal clearance. Any part of the preparation that has insufficient occlusal clearance will be readily detectable as a thin spot in the wax. Additional tooth structure should be removed from the indicated areas and rechecked.

The occlusal reduction and functional cusp bevel are planed smooth with a no. 171L bur now *or* when the bur is used to instrument the seating groove. There should not be sharp angles or ridges where the planes or bevel join. If there are, they should be removed with the tapered fissure bur.

The buccal and lingual walls are reduced with a torpedo diamond, whose sides will produce the desired axial

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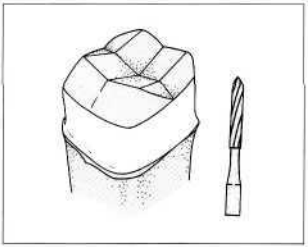


Fig 10-5 Chamfer and axial finishing: Torpedo bur.

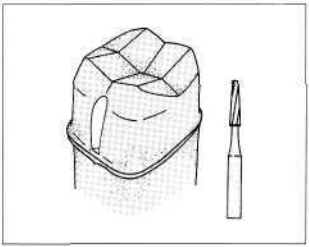


Fig 10-6 Scaling groovy: No. 171L bar.

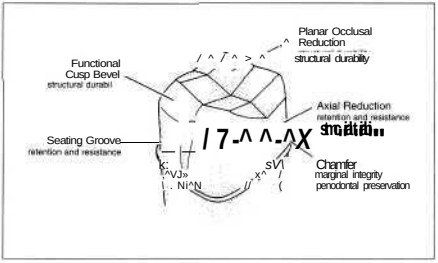


Fig 10-7 Features of a mandibuiar full metal crown preparation and the function served by each.

reduction while its tapered tip forms a chamfer finish line (Fig 10-3). A definite, even finish line is necessary to enable the fabrication of a well-fitting restoration,[8] and the chamfer is the best for providing the bulk needed for strength while still allowing good adaptation.[1]

The initial proximal cuts are made with a short needle diamond (Fig 10-4). The thin diamond is worked through the proximal area in an occlusogingival or buccolingual "sawing" motion, carefully avoiding the adjacent teeth. Once sufficient maneuvering room has been obtained, the torpedo diamond is introduced to plane the walls while simultaneously forming a chamfer as the interproximal gingival finish line.

All of the axial surfaces are smoothed with a torpedo carbide finishing bur whose size and shape enable it to finish the chamfer finish line as well (Fig 10-5). Special care should be taken in rounding the corners from the buccal or lingual surfaces to the proximal surfaces to insure that the finish line will be smooth and continuous. The final step in the full veneer preparation is the placement of a seating groove (Fig 10-6). It will prevent any rotational tendencies during cementation, and it will help guide the casting to place. The groove is formed with a no. 171L bur and is placed in the axial surface with the greatest bulk. This usually will be on the buccal surface of mandibuiar preparations and on the lingual surface of maxillary preparations. On preparations for long-span fixed partial dentures, there should be a buccal and a lingual groove io increase the resistance to mesiodistal movement. The features of a preparation for a full veneer metal crown and the function served by each are shown in Fig 10-7

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Metal-Ceramic Crowns

The *metal-ceramic restoration,* also called a porcelain-fused-to-metal restoration, consists of a ceramic layer bonded to a thin cast metal coping that fits over the tooth preparation. Such a restoration combines the strength and accurate fit of a cast metal crown with the cosmetic effect of a ceramic crown. With a metal understructure, metal-ceramic restorations have greater strength than restorations made of the ceramic alone. Friedlander et al found the metal-ceramic restoration to be 2.8 times as strong.[9] As a result, the longevity of metal-ceramic restorations is greater, and it can be used in a wider variety of situations, including the replacement of missing teeth with fixed partial dentures.

Since the restoration is a combination of metal and ceramic, it is not surprising that the tooth preparation for it is likewise a combination. There is deep reduction on the facial surface to provide space for the coping and a ceramic layer thick enough to achieve the desired cosmetic result. On the lingual surface and the lingual aspects of the proximal surfaces, there is shallower reduction similar to that used for a full metal crown. There may be a wing on each proximal surface where the deep facial reduction ends and the shallower proximal reduction begins.10

Adequate reduction is essential to achieving a good cosmetic result. Without the space for a sufficient thickness of ceramic material, two things can happen. *(1)* the restoration will be poorly contoured, adversely affecting both the cosmetic effect of the crown and the health of the surrounding gingiva, and *(2) the* shade and translucency of ihe restoration will not match adjacent natural teeth.

Anterior Metal-Ceramic Crowns

A uniform reduction of approximately 1.2 mm is needed over the entire facial surface. To achieve adequate reduction without encroaching upon the pulp, the facial surface must be prepared in two planes that correspond roughly to the two geometric planes present on the facial surface of an uncut tooth (Fig 10-8). If the facial surface is reduced in one plane that is an extension of the gingival plane, the incisal edge will protrude, resulting in a bad shade match or an overcontoured "block." If the facial surface is prepared in one plane that has adequate facial reduction in the incisal aspect, the facial surface will be overtapered and too close to the pulp.

Armamentarium

1. Laboratory knife with no. 25 blade
2. Silicone putty and accelerator
3. Handpiece
4. Flat-end tapered diamond
5. Small wheel diamond
6. Long needle diamond
7. Torpedo diamond
8. Torpedo bur
9. H158-012 radial fissure bur
10. RS-1 binangle chisel

If an index is made before the preparation is begun, it will be possible to have a positive check on reduction produced by the preparation. If the contours of the existing tooth are correct, the index can be made mtraorally while waiting for the anesthetic to take effect. However, if the tooth is badly broken down, or if contours are to be changed in the finished restoration, the index should be made from a preoperative wax-up on the diagnostic cast.

One-half scoop of putty is mixed with the appropriate amount of accelerator and kneaded in the palm of the hand until all streaks of the accelerator have disappeared. The putty is then adapted with a thumb and forefinger over the tooth to be prepared (Fig 10-9). It should be allowed to polymerize on the tooth, which should take about 2 minutes. The index should cover the entire labial and lingual surface of the tooth to be prepared, plus the corresponding surfaces of at least one adjacent tooth (Fig 10-10).

The index is then removed from the teeth. A laboratory knife with a no. 25 blade is used to cut along the incisal edges of the tooth imprints to separate the index into a labial and a lingual half (Fig 10-11). The lingual half is set aside for the time being. The labial portion of the index is cut from mesial to distal across the imprints of the labial surfaces of the teeth to produce an incisal and a gingival half (Fig 10-12).

The gingival half of the labial portion is positioned on the teeth to insure that it is closely adapted to the labial surfaces (Fig 10-13). After removing the labial index, the lingual index is put in position and its adaptation to the incisal edges of the teeth is checked (Fig 10-14).

The labial and lingual indices are set aside until the preparation is completed. Then the gingival half of the labial index is positioned and checked for adequate labial clearance for a metal coping and porcelain (Fig 10-15). If the reduction is inadequate, the index is removed from the mouth and more tooth structure must be removed. The incisal clearance is checked by putting the lingual index in place and evaluating the distance between the incisal edge of the prepared tooth and the incisal edge of the tooth imprint on the index (Fig 10-16).

The initial step in the preparation for a metal-ceramic crown is the placement of depth-orientation grooves on the labial and incisal surfaces with a flat-end tapered diamond. These orientation cuts, recommended by Preston[10] and Miller,[11] are a means of judging the amount

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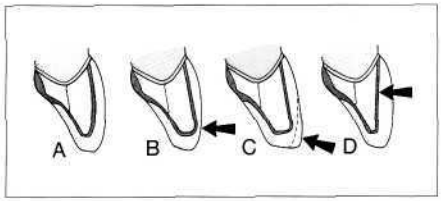


Fig 10-8 It is important to reduce the labial surface in two planes to receive a metal-ceramic restoration (A). If only one plane is produced, opaque porcelain may show through (B), the labial surface may be overcontoured (C), or the pulp may be encroached upon (D).

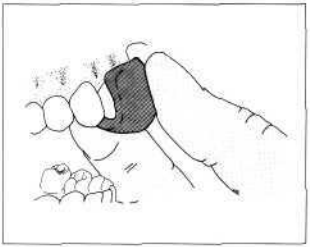


Fig 10-9 Mold silicone putty on the labial and lingual surfaces of the tooth to be prepared and the teeth adjacent to it.

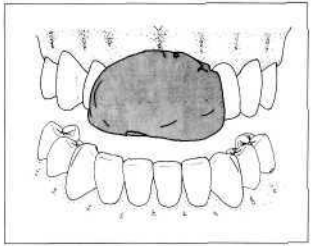


Fig 10-10 The index should contact the labial and lingual surfaces of the tooth on either side of the tooth to be prepared.

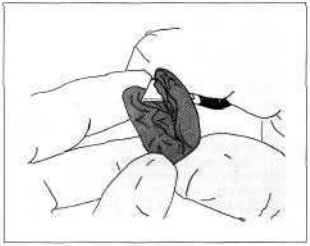


Fig 10-11 Cut the index into a labial and a lingual half.

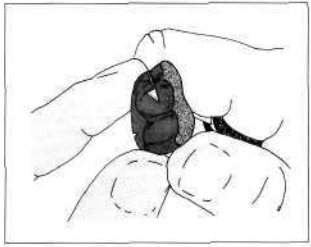


Fig 10-12 Cut the labial half of the index into a gingival and an incisal half.

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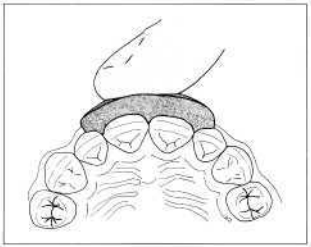


Fig 10-13 Place the gingival half of the index on the teeth to see if it fits accurately.

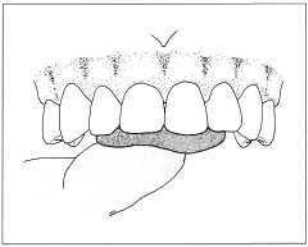


Fig 10-14 Place the lingual index in position to check its accuracy.

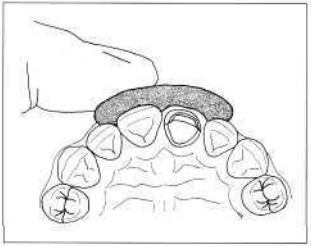


Fig 10-15 Position the gingival half of the index over the preparation to check the labial reduction.

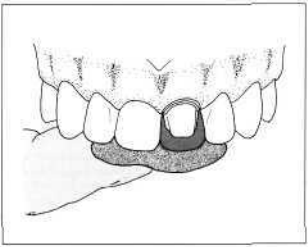


Fig 10-16 Place the lingual index in position to evaluate the incisal reduction.

of tooth structure to be removed. The full diameter of an instrument of known dimension is sunk into the tooth. The depth of reduction can be measured using the uncut outer surface o(the remaining tooth structure as a reference point.[11] If reduction is done without grooves, time will be wasted in repeatedly rechecking reduction with the index.

The labial grooves should be cut in two sets: one set parallel with the gingival half of the labial surface and one set parallel with the incisal half of the labial surface (Fig 10-17). These grooves should be 1.2 mm deep. The incisal grooves should be cut all the way through the incisal edge and should extend 2.0 mm gingivally.

Incisal reduction is done with the flat-end iapered diamond so that it parallels the inclination of the unprepared incisal edge (Fig 10-18). This is done first to allow easy instrument access to the axial surfaces and the gingival finish line. Inadequate incisal reduction results in poor incisal translucency in the finished restoration.

Reduction of the incisal portion of the labial surface is done with the same flat-end tapered diamond. All tooth structure is planed off to the depth of the orientation grooves (Fig 10-19). The gingival portion of the labial surface is likewise reduced to the depth of the grooves with the flat-end tapered diamond. The reduction is carried around the labioproximal line angles to a point 1.0

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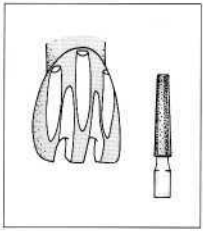


Fig 10-17 Depth-orientation grooves: Flat-end tapered diamond.

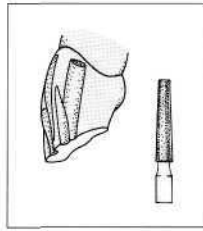


Fig 10-18 Incisal reduction: Flat-end tapered diamond.

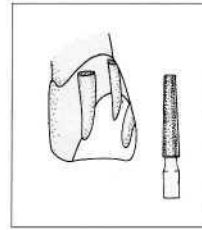


Fig 10-19 Labial reduction (incisal half): Flat-end tapered diamond.

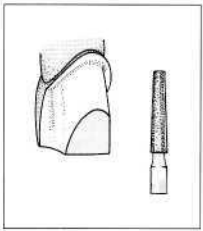


Fig 10-20 Labial reduction (gingival half): Flat-end tapered diamond.



Fig 10-21 Lingual reduction: Small wheel diamond.



Fig 10-22 Initial proximal reduction: Long needle diamond.

mm lingual to the proximal contacts (Fig 10-20). Although the resulting wings of tooth structure can provide some resistance to rotation, that is not the primary reason for their existence. They conserve tooth structure, if in fact there is still sound tooth structure left on the proximal surfaces. It is important that the portion of each wing that faces labially has the same inclination as the gingival portion of the labial surface.

The lingual surface is reduced with a small wheel diamond to obtain a minimum of 0.7 mm of clearance with the opposing teeth (Fig 10-21). Those portions of the lingual surface that will have a ceramic veneer should have 1.0 mm of clearance. The junction between the cingulum and the lingual wall must not be overreduced. Overshortening the lingual wall will reduce retention.

A long needle diamond is used to complete access through the proximal areas to minimize the chances of nicking the adjacent teeth (Fig 10-22). Much of the axial reduction in the region of the proximal contact will have been accomplished already by the flat-end tapered diamond. The lingual aspect of the proximal axial walls, as well as the lingual surface, are reduced with the torpedo diamond (Fig 10-23). The lingual and proximal axial surfaces are smoothed with the torpedo bur, accentuating the chamfer on the lingual and proximal surfaces at the same time (Fig 10-24).

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Fig 10-23 Lingual axial reduction: Torpedo diamond.



Fig 10-24 Axial finishing: Torpedo bur.



Fig 10-25 Axial and shoulder finishing: Radial fissure bur.

An H158-012 radial fissure bur is used to smooth the labial surface (Fig 10-25). All angles and edges on the preparation are rounded with the sides of the bur to facilitate seating of the restoration later At the same time that the labial surface is being planed by the side of the bur, the end is forming a radial shoulder finish line.

Shoulders have been advocated for gingivofacial finish lines of metal-ceramic preparations alone'?-[18] or with narrow bevels.[1017»20] Some investigators have reported that metal-ceramic crowns with metal gingivofacial margins made over shoulder finish lines distort less during porcelain firing.[21»22] A possible explanation is that the shoulder configuration provides space for an internal rib of metal to buttress the margin.">23 Other investigators have reported not finding a difference in marginal fit. They hypothesize that marginal gaps following ceramic firing may be caused either by technical difficulties in forming a knife edge of metal and ceramic[24] or by differences in metal/ceramic combinations.?[5]

However, there is a compelling reason for not using a metal margin at all. The metal collar that accompanies a bevel on a shoulder[26] often requires the finish line to be placed deep in the gingival sulcus to hide the metal.[27] If some form of shoulder without a bevel is used, an all-ceramic margin can be fabricated. This eliminates a metal collar at the facio gingival margin of the finished metal-ceramic restoration, and there is no need to bury the margin beneath the gingiva

Quanlitative evaluations of the marginal fit of all-ceramic shoulders on metal-ceramic crowns have found satisfactory adaptation of the ceramic to the preparation finish line. Belser et al reported in vivo marginal discrepancies of 46 jim on cemented metal-ceramic crowns with all-ceramic facial margins.[23] They found no significant differences among crowns with all-ceramic margins and those with metal collar margins over shoulder and beveled shoulder finish lines. In vitro studies by West and associates[29] and Hunt et al[30] found minimal marginal discrepancies in all-ceramic shoulder margins on metal-ceramic crowns. Of course, a dentist can use all-ceramic margins on metal-ceramic crowns only if the technician is capable of producing restorations with accurate ceramic margins.

Zena et al demonstrated that all-ceramic margins made over hand-planed shoulders fit significantly better than margins made over finish lines cut solely with rotary instruments.[31] However, if a conventional enamel chisel is used for planing a radial shoulder, the sharp angles at the ends of the cutting blade will destroy the rounded internal angle of the finish line (Fig 10-26).

A modified 15-8-8 binangle chisel, the RS-1 (Suter Dental Mfg, Chico, CA), is recommended to avoid this problem (Fig 10-27). This instrument has a hoe (pull stroke) blade at both ends, unlike a conventional 15-8-8 binangle chisel, which has a hoe (pull stroke) blade at one end and a chisel (push stroke) blade at the other (Fig 10-28). One corner of one RS-1 blade is rounded with a mounted Arkansas stone (Fig 10-29, A), and the opposite corner is rounded on the other end (Fig 10-29, B).

One end, with the rounded corner against the gingivoaxial "angle," is used to instrument the radial shoulder on one-half of the preparation (Fig 10-30). The other end, with its modified corner also against the rounded gingivoaxial junction, is used to smooth the finish line on the other half of the preparation. The 1,5-mm-wide blade will extend over the actual finish line, which is 1.2 to 1.5 mm wide. This will remove any lip of enamel that might extend occlusally from the cavosurface angle.

The features of a preparation for an anterior metal-ceramic restoration and the function served by each are shown in Fig 10-31.

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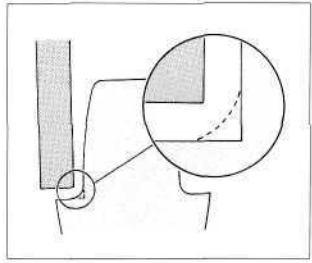


Fig 10-26 The sharp corners of a conventional chisel will gouge the gingivoaxial angle *(inset)* of a radial shoulder.

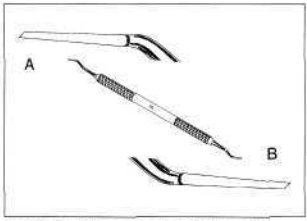


Fig 10-27 The RS-1 is a modified 15-8-8 chisel with the same hoe (pull stroke) blade on both ends (A and B).

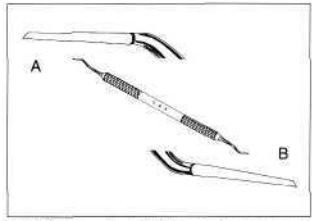


Fig 10-28 A conventional 15-8-8 binangle chisel has a hoe (pull stroke) blade on one end (A) and a chisel (push stroke) blade at the other (B).

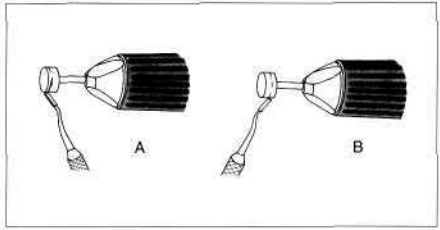


Fig 10-29 Round an angle at one end of the RS-1 (A) and the opposite angle on the other end (B).

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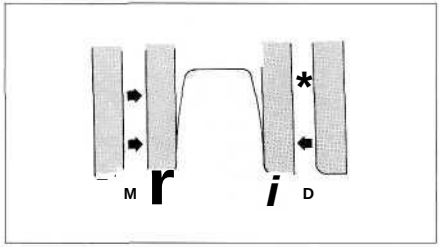


Fig 10-30 The rounded corner of one end of the RS-1 is placed against the gingivoaxial angle while planing the mesial half of the shoulder IM). The other end is used to instrument the distal half of the finish line (D).

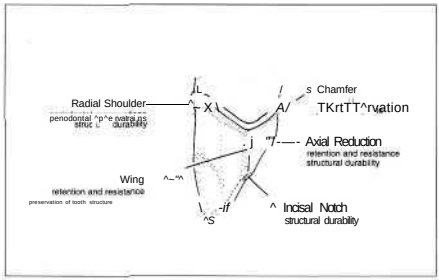


Fig 10-31 Features of an anterior metal-ceramic preparation and the function served by each.

Posterior Metal-Ceramic Crowns

The use of metal-ceramic crowns on posterior teeth allows the creation of an esthetic restoration on a posterior tooth needing a full crown in the appearance zone. Maxillary premolars, maxillary first molars, and mandibular first premolars are almost always in the appearance zone. Mandibular second premolars also can fall into this category. Maxillary second molars and mandibular molars may require metal-ceramic crowns if a patient will not accept all-metal crowns on those teeth.

Routinely placing metal-ceramic crowns on all premolars and molars is overtreatment because of the additional tooth structure that must be destroyed to accommodate the combined thickness of metal and ceramic. Often there is added expense for the patient because of higher laboratory fees, as well as an increased risk of failure from ceramic veneer fracture.

The routine use of all-ceramic occlusal surfaces has been criticized.[32] This restoration design offers maximum cosmetic effect when required by location in a highly visible area or by patient preference. Patients who demand ceramic occlusai surfaces should know of the potential problems. The use of all-ceramic occlusal surfaces requires the removal of more tooth structure, and the completed restorations pose a threat to the structural integrity of opposing occlusal surfaces. Conventional glazed dental porcelain is approximately 40 times as

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abrasive as gold to tooth enamel[33] Preparations for metal-ceramic crowns should be done with a plan for the extent of ceramic coverage in mind, since the areas to be veneered with ceramic require deeper reduction than those portions of the tooth that will be overlaid with metal alone.

Armamentarium

1. Laboratory knife with no. 25 blade
2. Silicone putty and accelerator
3. Handpiece
4. Flat-end tapered diamond
5. Short needle diamond
6. Torpedo diamond
7. Torpedo bur
8. H158-012 radial fissure bur
9. RS-1 bmangle chisel

Before the preparation is begun, silicone putty is adapted (o the facial, lingual, and occlusal surfaces of the tooth to be prepared as well as to one tooth on each side. After polymerization, a midsagittal index can be formed by cutting the silicone in half along the faciolingual midline of the tooth to be prepared. The putty is placed back on the tooth to insure good adaptation. If the clinical crown of the tooth being restored is severely damaged, the index should be made from a diagnostic wax-up.

A facial index is made by cutting through the silicone along the facial cusps of the teeth. The facial piece is divided along a line midway between the cervical lines of the teeth and the facial cusp tips. The occlusal portion is discarded and the gmgival portion is used as an index.
The occlusal reduction is begun by making depth-orientation grooves with a round-end tapered diamond. In the areas where there will be ceramic coverage, reduction should be 1.5 mm[34] to 2.0 min.[101,5] The occlusal reduction is completed by removing the strips of intact enamel between the depth-orientation grooves with the same diamond. The reduction should take the form of definite planes reproducing the general occlusal morphology[36] or the basic geometric shape of the occlusal surface (Fig 10-32).

The functional cusp bevel, which allows a uniform bulk of restorative material on the lingual inclines of maxillary lingual cusps and the facial inclines of mandibular facial cusps, is also begun with depth-orientation grooves (Fig 10-33). The depth required will be 1.5 mm if the coverage will be metal only, and 2.0 mm if the metal will be veneered with ceramic. The functional cusp bevel is completed by removing the tooth structure between the depth-orientation grooves. The angulation of the bevel approximates the inclination of the opposing cusps,

A no. 171L bur is used to smooth the planes of the occlusal reduction to remove any roughness or pits that might interfere with the complete seating of the finished restoration. Any sharp corners or edges on the preparation that might cause problems in impression pouring, investing, casting, and ultimately in the seating of the completed crown should be rounded over.

The flat-end tapered diamond is aligned with the occlusai segment of the facial surface and three vertical grooves are cut in the occlusal portion of the facial surface. These are nearly the full diameter of the instrument, fading out gmgivally (Fig 10-34). The same diamond is aligned with the gingival component of the facial surface, and the side of the instrument is used to cut into the tooth surface. The full diameter of the instrument must cut into the tooth. The instrument tip should be slightly supragingival at this point, even if the intended location of the finish line is flush with or slightly below the gingival crest. At least two more orientation grooves should be placed near the line angles of the tooth.

All tooth structure remaining between the depth-orientation grooves in the occlusal segment of the facial surface is removed with the flat-end tapered diamond (Fig 10-35). The gingival portion of the facial surface is then reduced, extending it well into the proximal surface (Fig 10-36), If facial reduction of less than 1.2 mm is done for a base metal-ceramic crown or 1.4 mm for a noble metal-ceramic crown, the restoration will be either opaque or overcontoured.

The proximal axial reduction is begun with a short needle diamond (Fig 10-37). Its narrow diameter allows interproximal reduction without nicking adjacent teeth. The instrument can be used with an up-and-down motion on the facial aspect of the interproximal tooth structure, or it can be used on the occlusal portion with a faciolingual movement. Initially, the objective is to achieve separation between the teeth without overtapering the prepared walls or mutilating the adjacent tooth. The proximal axial surfaces are then planed with the needle diamond.
The lingual axial wall is reduced with a torpedo diamond (Fig 10-38). Enough tooth structure is removed on both the lingual and proximal axial walls to create a distinct chamfer finish line wherever there will not be a ceramic veneer. The chamfer finish line and the axial surfaces adjacent to it are smoothed with a torpedo carbide finishing bur. All axial surfaces that will be veneered only with metal are finished in this way.

The facial surface and those parts of the proximal surfaces to be veneered with ceramic are smoothed with an H158-012 radial fissure bur (Fig 10-39). At the lingual-most extension of the facial reduction, lingual to the proximal contact, the transition from the deeper facial reduction to the relatively shallower lingual axial reduction results in a vertical wall or "wing" of tooth structure. The wings must not be undercut with the facial or lingual axial walls of the preparation.

If the shoulder and wings are not lingual to the proximal contact, the proximal area of the ceramic veneer will lack translucence. If there was an amalgam restoration in the tooth prior to this preparation, the wing is made to coincide with the lingual wall of the amalgam's proximal box. If the entire proximal surface is to be veneered with ceramic, the shoulder is extended across the proximal surface with no wing.

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Fig 10-32 Planar occlusal reduction: Round-end tapered diamond and no. 171 bur.



Fig 10-33 Functional cusp bevel: Round-end tapered diamond and no. 171 bur.



Fig 10-34 Depth-orientation grooves: Flat-end tapered diamond.

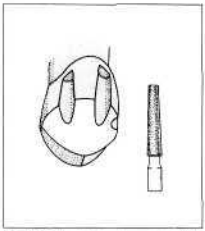


Fig 10-35 Facial reduction, gingival half: Flat-end tapered diamond.

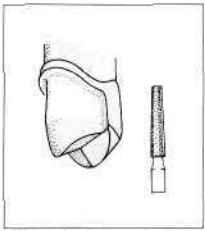


Fig 10-36 Facial reduction, gingival half: Flat-end tapered diamond.

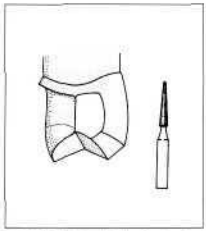


Fig 10-37 Proximal axial reduction: Short needle diamond.



Fig 10-38 Lingual axial reduction and finishing: Torpedo diamond and bur.



Fig 10-39 Facial axial and radial shoulder finishing: Radial fissure bur.

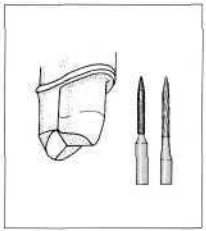


Fig 10-40 Gingival bevel: Flame diamond and finishing bur.

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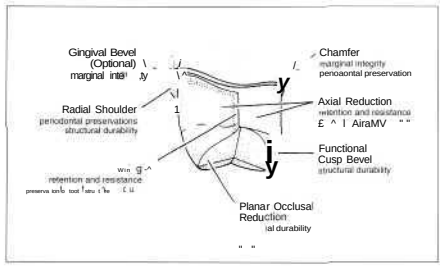


Fig 10-41 Features of a preparation for a metal-ceramic crown on a posterior Tooth and the function served by each.

The radial shoulder, started with the flat-end tapered diamond at the time the facial reduction was accomplished, is finished now with the radial fissure bur. On highly visible posterior teeth, such as the maxillary premolars, an all-ceramic margin is frequently used to achieve a good esthetic result without intruding into the gingival sulcus. The 1.0-mm-wide shoulder is smoothed by planing it with the RS-1 modified binangle chisel, which will preserve the rounded internal angle created by the radial fissure bur. Any "lip" or reverse bevel of enamel at the cavosurface angle should be removed. Small, sharp edges in this area may not be reproduced when the impression is poured, and they are susceptible to fracture on the cast or on the tooth in the mouth.

There are occasions when a shoulder with a bevel is the finish line of choice: when esthetic needs are not as critical or the dental technician is unable to consistently produce a precise all-ceramic margin. A narrow bevel, no wider than 0.3 mm, can be placed on the shoulder with the tip of a flame-shaped diamond (Fig 10-40). The bevel should be kept narrow, since the metal collar on the resulting crown must be as wide as the bevel. The bevel is easier to wax and cast to if the diamond is leaned toward the center of the tooth as much as possible. The bevel is finished with an H48L-010 flame-shaped carbide finishing bur to create a finish line that is as clear as possible. The features of a preparation for a posterior metal-ceramic restoration and the function served by each are shown in Fig 10-41.

AM-Ceramic Crowns

The all-ceramic crown differs from other cemented veneer restorations because it is not cast in gold or some other metal. It is capable of producing the best cosmetic effect of all dental restorations. However, since it is made entirely of ceramic, a brittle substance, it is more susceptible to fracture The development of dental porcelain reinforced with alumina in the 1960s created renewed interest in the restoration.[37] Dicor cast glass ceramic, Hiceram, In-ceram, and IPS Empress restorations have maintained the interest of the profession over the past decade.

Preparations for this type of crown should be left as long as possible to give maximum support to the porcelain. An overshortened preparation will create stress concentrations in the labiogingival area of the crown,[3*] which can produce a characteristic "half-moon" fracture in the labiogingival area of the restoration.[38,40] A shoulder of uniform width (approximately 1 mm) is used as a gingival finish line to provide a flat seat to resist forces directed from the incisal.[3841] The incisal edge is flat and placed at a slight inclination toward the linguogingival to meet forces on the incisal edge and prevent shearing.[4243] Finally, all sharp angles of the preparation should be slightly rounded to reduce the danger of fracture caused by points of stress concentration.[38,43]

The position of the tooth in the arch, factors relating to occlusion, and morphologic features of the tooth all should be weighed when an all-ceramic crown is considered for a restoration. All-ceramic crowns are best suited for use on incisors. If they are used on other teeth, patients should know that there is an increased risk of fracture.

Use of the all-ceramic crown should be avoided on teeth with an edge-to-edge occlusion that will produce

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stress in the incisal area of the restoration. It likewise should not be used when the opposing teeth occlude on the cervical fifth of the lingual surface. Tension will be produced, and a "half-moon" fracture is likely to occur. Teeth with short cervical crowns also are poor risks for all-ceramic crowns because they do not have enough preparation length to support the lingual and incisal surfaces of the restoration.

Armamentarium

1. Handpiece
2. Flat-end tapered diamond
3. Small wheel diamond
4. H158-012 radial fissure bur
5. RS-1 binangle chisel

Depth-orientation grooves are placed on the labial and incisal surfaces with the flat-end tapered diamond before any reduction is done (Fig 10-42). Without grooves it is impossible to accurately gauge the depth of reduction done on the labial surface. The grooves are 1.2 to 1.4 mm deep on the labial and 2.0 mm deep on the incisal. Three labial grooves are cut with the diamond held parallel to the gingival one-third of the labial surface. A second set of two grooves is made parallel to the incisal two-thirds of the uncut labial surface. The labial surface of an all-ceramic preparation is done in two planes to achieve adequate clearance for good esthetics without encroaching on the pulp.[*2]

Incisal reduction is done with the flat-end tapered diamond so that it will be possible lor instruments to reach the finish line area of the preparation in subsequent steps. From 1.5 to 2.0 mm of tooth structure is removed (Fig 10-43).

The tooth structure remaining between the depth-orientation grooves on the incisal portion of the labial surface is planed away (Fig 10-44). The gingival portion of the labial surface is reduced with the flat-end tapered diamond to a depth of 1.2 to 1.4 mm. This reduction extends around the labioproximal line angles and fades out on the lingual aspects of the proximal surfaces (Fig 10-45). The end of the flat-end tapered diamond bur will form the shoulder finish line, while the axial reduction is done with the sides of the diamond. The shoulder should be a minimum of 1.0 mm wide. Lingual reduction is done with the small wheel diamond, being careful not to overreduce the junction between the cingulum and the lingual wall (Fig 10-46). Overshortening the lingual wall will reduce the retention of the preparation.

Reduction of the lingual axial surface is done with the flat-end tapered diamond (Fig 10-47). The wall should form a minimum taper with the gingival portion of the labial wall. The radial shoulder is at least 1.0 mm wide and should be a smooth continuation of the labial and proximal radial shoulders. All-ceramic crowns made over shoulder finish lines exhibit greater strength than those made over chamfers.[944] All of the axial walls should be smoothed with an H158-012 radial fissure bur, accentuating the shoulder at the same time (Fig 10-48). All sharp angles should be rounded over at this time. The RS-1 modified binangle chisel is used to smooth the shoulder, removing any loose enamel rods at the cavosurface angle. Care must be taken not to create undercuts in the axial walls where they join the shoulder. The features of a preparation for an all-ceramic crown and the purpose served by each are shown in Fig 10-49.

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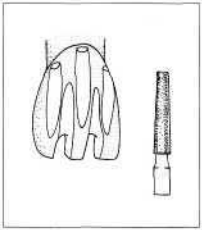


Fig 10-42 Depth-orientation grooves: Flat-end tapered diamond.

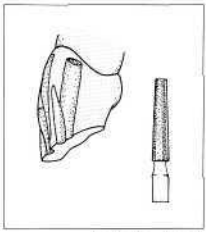


Fig 10-43 Incisal reduction: Flat-end tapered diamond.

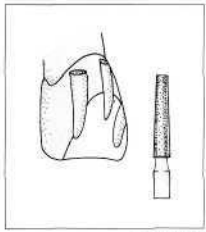


Fig 10-44 Labial reduction (incisal half): Flat-end tapered diamond.



Fig 10-45 Labial reduction (gingival half): Flat-end tapered diamond.



Fig 10-46 Lingual reduction: Small wheel diamond.



Fig 10-47 Lingual axial reduction: Flat-end tapered diamond.



Fig 10-48 Axial wall and radial shoulder finishing: Radial fissure bur.

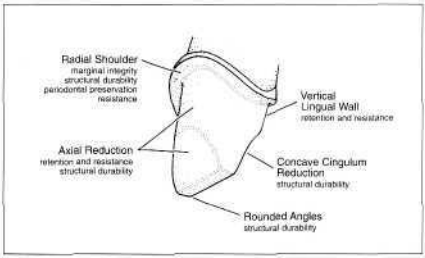


Fig 10-49 Features of an all-ceramic crown preparation and the funrlion served by each.

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Chapter 12

Preparations for Intracoronal Restorations

The intracoronal inlay is the simplest of the cast restorations and has been used for the restoration of occlusal, gingival, and proximal lesions. Intracoronal restorations utilize "wedge" retention, which exerts some outward pressure on the tooth. This pressure is exerted first during try-in and cementation, but it occurs again when occlusal force is applied. For the restoration to be successful, there must be some form of counteraction. When an inlay is placed in a tooth with ample bulk of looth structure, the tooth structure itself resists the force.

The use of cast metal inlays, at one time considered the mark of quality restorative care, has declined in recent years. A group of US dental educators concluded in 1979 that: "Cast gold restorations should be limited to those teeth which need cusp coverage for protection and reinforcement of the tooth. The true cast gold inlay is no longer a reasonable consideration in the conservative treatment of unrestored teeth.[1] A survey of North American dental faculty in the early 1980s indicated that nearly one-third of their schools taught limited use of inlays, or none at all.[2]

The indications for an inlay are virtually the same as for an amalgam restoration. The inlay simply replaces missing tooth structure without doing anything to reinforce that which remains.[3] If the tooth requires protection from occlusal forces, the protection must be gained by the use of some other type of restoration that incorporates a veneer of casting alloy over the occlusal surface.[4] Inlays tend to wedge cusps apart,[5] and a lone-standing unsupported cusp is at risk of fracture.[6]

Mechanical cusp height is normally equal to anatomic cusp height, measured from cusp tip to the bottom of the central groove. An occlusal intracoronal preparation increases mechanical cusp height to a hazardous extent,[7] as it becomes the distance from the cusp tip to the gingival extension of the preparation. In premolars, this elongation of the lever arm can increase stress.

Stress concentrations can manifest themselves in various forms of clinical failure. The most dramatic and the most evident is the loss of a whole cusp because of fracture. Failure also may occur in less obvious ways. The cement seal can rupture, with ensuing marginal leakage, when tooth structure flexes in weakened cusps and preparation walls bend without actually fracturing[8] or spring away from the restoration.[7] This may not become apparent for some period of time, but it would eventually surface as an open margin, possibly with recurrent caries This type of failure may escape being identified as an ill-designed restoration that did not protect the tooth from destructive, occlusally generated stresses.

Analysis has detected greater stress when intracoronal preparations are wide.[9,10] Because a wider isthmus can lead to failure,[9,10] and an inlay that is one-third the faciolingual width of the occlusal surface can wedge the cusps apart,[13] the recommended isthmus width has been reduced to one-fourth the intercuspal distance.[14]

Vale[5] found a 35% decrease in the fracture resistance of a maxillary premolar when the isthmus of a proximo-occlusal preparation was widened from one-fourth to one-third the intercuspal distance. Mondelli et al[16] reported decreases of 42%, 39%, and 29% with similar isthmus widening of proximo-occlusal. occlusal, and MOD preparations, respectively.

Depth, combined with width, decreased the fracture strength of teeth in studies by Blaser and associates[11] and Re et al.[17] This corroborates clinical observations of inlays acting as wedges between the facial and lingual cusps of teeth.[5,7] Deepening an isthmus to increase resistance, or inlay strength, is not a good practice.

Proximo-occlusal Inlays

A proximo-occlusal inlay is indicated for premolars or molars, with minimal caries or previous restoration, that need a mesio-occlusal or disto-occlusal restoration. It offers a superior material and margins that will not deteriorate with time. The restoration will be visible on premolars, although careful extensions on mesiobuccal flares should keep the display minimal. MOD inlays that can be kept narrow are acceptable for molars. If a premolar is damaged badly enough to warrant even a conservative MOD cast restoration, that restoration should be an onlay. Class 2 inlays should be used in mouths that have shown a low caries rate for some time preceding the placement of the restoration. It is a dubious service to place a two-surface restoration in a tooth that has a high likelihood of requiring that the third surface be restored in the not-too-

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Fig 12-1 Occlusal outline: No. 170 bur.

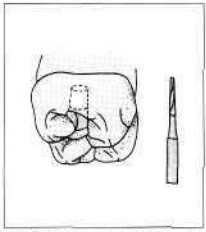


Fig 12-2 Undermining marginal ridge: No. 169L bur.

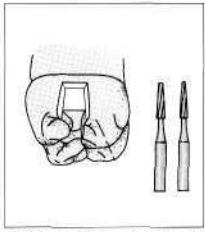


Fig 12-3 Proximal box: No. 169L and 170L burs.

distant future. Patients with accumulations of plaque or a recent history of caries, or those who are still in adolescence, are poor candidates for inlays.

Armamentarium

1. Handpiece
2. No. 170L bur
3. No. 169L bur
4. Flame diamond
5. Flame bur
6. Enamel hatchet
7. Binangle chisel
8. Gingival margin trimmer

Use a no. 170L bur to make the occlusal outline (Fig 12-1). Initial penetration is made in a fossa with the edge of the bur tip. The isthmus is then cut to its final extension by following the central groove and any deep or faulty grooves leading to it. The extension should be conservative because an occlusal bevel will widen it later.

A distinct dovetail extends facially, enhancing resistance and retention. The pulpal floor should be flat, at an even depth of approximately 1.5 mm, and perpendicular to the path of insertion for maximum resistance.[7] The outline should avoid occlusal contacts marked with articulating paper. The initial cut extends far enough to undermine the marginal ridge, which will be removed shortly. The walls of the isthmus will be slightly inclined by the bur used to cut them. Check the walls to make sure there are no undercuts. Do not err in the opposite direction by overtapering the walls.

If the tooth being prepared has not been previously restored, complete the undermining of the marginal ridge with a no. 169L bur. Do not cut all the way through the enamel to the outer surface at this time. Penetrate in an apical direction with the bur, with the tip apical to the contact (Fig 12-2). Do not be too conservative with the gingival extension, since box length is an important factor in inlay retention.[14] Cut buccally and lingually to the approximate width of the proposed box, just inside the cementoenamel junction.

Break through the undermined enamel to rough out the proximal box, using either the no. 169L bur or an enamel chisel. Use the 169L bur to finish smoothing the box. Extend it buccally and lingually just far enough to barely break contact with the adjacent tooth (Fig 12-3). The final extension will be achieved when the facial and lingual flares are placed. Widen the isthmus where it joins the box, rounding any angle in the area where they meet.

The buccoaxial and linguoaxial line angles of the box are accentuated with a no. 169L bur. The same bur is also used to form the facial and lingual walls of the box, and they are smoothed with an enamel chisel. The box walls, not the angles, resist displacement.[14] Those walls should have a minimum degree of divergence of the facial and lingual walls to promote optimum retention and resistance. As taper increases, stress rises and retention decreases.

The pulpal floor of the isthmus and the gingival floor of the box should be flat. A gingival margin trimmer is used to form a V-shaped groove at the junction of the axial wall and the gingival floor of the box (Fig 12-4). This groove, sometimes referred to as the "Minnesota ditch,"[15] is placed to enhance resistance to displacement by occlusal forces.[19]

Flares are flat planes added to the buccal and lingual walls of the box using a flame diamond or an enamel hatchet (Fig 12-5). The hatchet is reserved for use in those areas where esthetics is an important consideration. The flares provide for the acute angle of gold to meet the finish line on the preparation. Check the flares to make sure that they "draw." The buccal flare leans slightly to the buccal; the lingual flare, slightly to the lingual: and both flares, slightly to the center of the tooth. A

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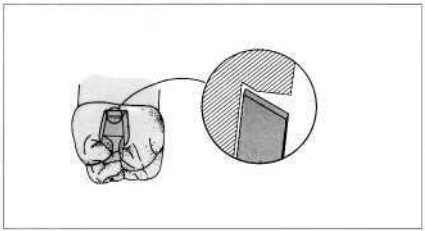


Fig 12-4 Gingivoaxial groove: Gingival margin trimmer.

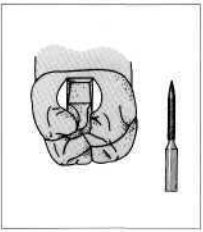


Fig 12-5 Proximal flares: Flame diamond.

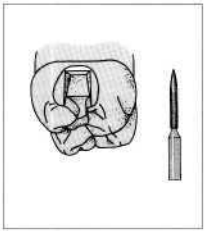


Fig 12-6 Gingival bevel: Flame diamond.

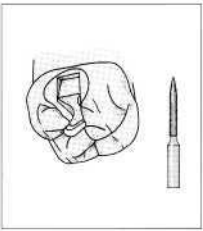


Fig 12-7 Isthmus bevel: Flame diamond.

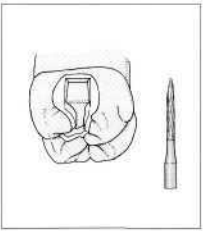


Fig 12-8 Bevel and flare finishing: Flame bur.

flare is cut equally at the expense of the wall of the box and of the outer enamel surface of the tooth. As a result, a flare is narrow at its gingival end and much wider at its occlusal end.

To start the flare, place the flame diamond in the proximal box and use the small-diameter tip to cut the cavosurface angle of the box from the gingival floor up. Continue the occlusally directed sweep of the diamond tip without changing the angle or direction of the instrument. The diamond should be cutting only when it is moving in the occlusal direction. If it is moved back and forth, the finish line may be rounded over.

The flame diamond is carried across the gingival cavosurface angle of the box, forming a gingival bevel on the box that is a smooth continuation of the buccal and lingual flares (Fig 12-6). Avoid creating undercuts where the gingival bevel joins the flares. Lean the flame diamond against the pulpal axial line angle. The bevel should lay between 30 and 45 degrees to provide an optimum blend of strength and marginal fit.[70] A gingival margin trimmer is unacceptable because it will produce a ragged finish line.

The inlay preparation is finished by placing a bevel on the occlusal isthmus with a flame diamond [Fig 12-7). If a shallow bevel is used in this location, the result will be a thin flash of gold that will probably extend into areas of occlusal contact. The bevel on the isthmus begins at the junction of the occlusal one-third and the gingival two-thirds of the isthmus walls, and should extend outward at an angle of 15 to 20 degrees.[31]

The bevel must be minimal, because compressive stress increases as the inclination of the bevel increases.[10] The bevel is likely to produce some stress, but it is a necessary risk to produce a finishable casting. Blend the occlusal bevel into the proximal flares to produce a smooth, continuous finish line. Use a flame carbide bur

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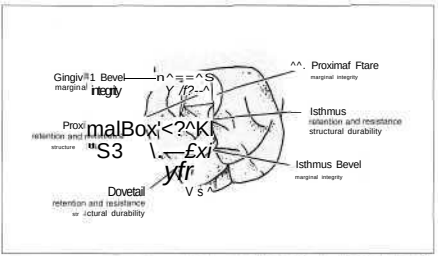


Fig 12-9 Futures of .ipi-oximo-occlusal inlay preparation and the function served by each.

to go over the flares and the bevels (Fig 12-8). The flame bur produces the most consistent bevel,[32] and carbide finishing burs will produce the smoothest finish lines.[23]

A torpedo diamond can be used to create the bevel; it will produce one that is slightly concave, as suggested by Tucker[24] The finish line is much more easily read. The features of the class 2 inlay preparation and the function served by each feature are shown in Fig 12-9.

Metal Inlay Variations

Other (ypes of metal inlays are used even less frequently than the class 2 restoration. A class 1 inlay can be used to restore a moderately sized occlusal lesion in the mouth of a patient with predominantly gold restorations in other teeth. The 1.0-mm-wide isthmus follows the central groove, ending short of the marginal ridges or transverse ridge, if there is one on the tooth.

The outline extends moderately into the facial and lingual grooves, with small "barbell" dovetails at each end (Fig 12-10). Besides increasing retention and resistance, these extensions place the finish line on the slopes of the triangular and marginal ridges, where the inlay margins can be finished more easily. A 15- to 20-degree bevel extends a third of the way down the sides of the isthmus wall. Overextending the bevel will make the restoration too wide, and the finish line will form such an obtuse angle with the enamel surface that it will be difficult to identify during margin finishing .

The class 3 inlay shows metal, making it unacceptable for incisors However, it is useful for restoring the distal surface of canines if a slight display of metal is acceptable to the patient.[25] A well-done inlay in a canine will look better than an amalgam restoration, last longer than a composite resin restoration, and be much less destructive than a porcelain crown. It is not commonly used, but the restoration does have a place.

The class 3 inlay preparation has a 1.0-mm-deep lingual dovetail at the incisal end of the cingulum that resists displacement (Fig 12-11).[56] The proximal box is prepared with a lingual approach to minimize the display of metal[21] An incisal approach will destroy excessive tooth structure as well as create an unesthetic restoration.

The class 5 inlay is used to restore severe abrasion?[6] or erosion as well as large caries on the gingivofacial aspect of molars (Fig 12-12). It cannot tie into other restorations without producing a poor marginal seal. The preparation should be 1.0 mm deep axially and extend to the line angles. The gingival finish line is supragingival, if damage permits, and approximately 0.5 mm above the jaw of the cervical rubber dam clamp placed for preparing the tooth.[21] The height of contour is the occlusal limit of the preparation.

To enhance retention and resistance,[3031] drill 0,6-mm-diameter pin holes to a depth of 3.0 mm at the proximal edges of the outline form. Place a 0.5-mm-wide. 45-degree bevel around the periphery of the preparation. For the impression, use a custom tray that draws buccally.

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Fig 12-10 Class 1 inlay preparation on a mandibular molar.

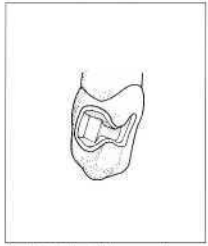


Fig 12-11 Class 3 inlay preparation on a maxillary canine.

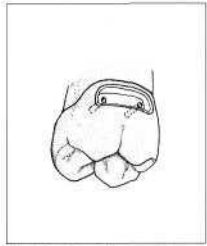


Fig 12-12 Class 5 inlay preparation on a maxillary molar.

MOD Onlays

The use of inlays to restore mesio-occluso-distal lesions in premolars is questionable. Occlusal force on an inlay produces stress along the sides of the restoration and at its base, as the inlay pushes against the tooth structure surrounding it. This could fracture the tooth,[32] so the inlay must be modified to distribute the load evenly over a wide surface. Stress analysis has shown that covering the occlusal surface with metal will do much to minimize the potentially damaging effects of stress in an intracoronal restoration (Fig 12-13).[1o, 33]

The MOD onlay is indicated for a variety of situations[3].

1. Broken down teeth with intact buccal and lingual cusps.
2. MOD restorations with wide isthmuses.
3. Endodontically treated posterior teeth with sound buccal and lingual tooth structure. (Access for root canal therapy weakens a tooth structurally, and the crown of the tooth must be protected after treatment is complete.)

There has been a renewed interest in the MOD onlay, based on an occiusion-centered approach to restorative dentistry rather than one that is solely tooth oriented. MOD onlays are significantly less retentive and resistant than three-quarter crowns[34] and should not be used as fixed partial denture retainers. They lack sufficient retention to successfully resist the additional forces placed on an abutment tooth by a fixed partial denture.

Fisher et al[31] showed that onlays protect teeth from the high stress concentrations at the walls and line angles of the isthmus that are found under inlays. Studies by Craig et al[3*] and Farah and associates[10] also showed the superiority of MOD onlays in protecting teeth from stress.

Armamentarium

1. Handpiece
2. Round-end tapered diamond
3. No. 171Lbur
4. No. 170L bur
5. No. 169Lbur
6. Flame diamond
7. Flame bur
8. Enamel hatchet

The previous restoration should be removed at this point. The occlusal reduction is done with a round-end tapered diamond to establish preparation length. About 1.5 mm of clearance is gained on the functional cusp and 1.0 mm on the nonfunctional cusp (Fig 12-14). Orientation grooves are used to gauge the depth of reduction. There should be one on the crest of each triangular ridge and one in each major developmental groove.

On a maxillary tooth where the nonfunctional facial cusp will be highly visible, do not overreduce the facio-occlusal angle or the restoration will show metal unnecessarily. The depth of the orientation grooves and the occlusal reduction should be about 0.5 mm at the line angle.

Occlusal reduction is accomplished by removing the tooth structure left between the depth-orientation grooves with the round-end tapered diamond. The reduction follows the original contours of the cusp,[315] reproducing the geometric inclined planes of the occlusal surface.[37] It has been hypothesized that this corrugated multiplanar design enhances restoration strength.[38]

A wide bevel is placed on the outer-facing inclines of the functional cusp with the round-end tapered diamond to insure an adequate bulk of metal on the functional

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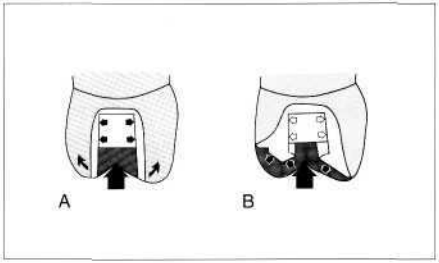


Fig 12-13 Occlusal forces applied to an MOD inlay produce stresses ibai tend to separate the cusps (A), while thi: same force applied to an MOD onlay is dissipated over a wide area in less destructive patterns (B).

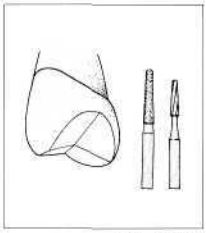


Fig 12-14 Plana, occlusal reduction: Round-end tapered diamond and no. 171L bur.



Fig 12-15 Functional cusp bevel: Round-end tapered diamond and no. 171L bur.



Fig 12-16 Occlusal shoulder: No. 171L bur.

cusp (Fig 12-15). The functional cusp bevel approximates the inclination of the cusps in the opposing arch, extending from the central groove on the mesial to the central groove on the distal surface.

Begin with depth-orientation cuts that are 1.5 mm deep at the cusp tip. They fade out along a line that will later be the occlusal shoulder, 1.0 mm apical to the lowest occlusal contact. Remove the tooth structure left between the orientation grooves. Smooth the occlusal reduction and funtional cusp bevel with the no. 171L bur. The inclined planes should be well defined, but there should be no sharp angles where they meet. Check the occlusal reduction visually in the facial half of the occlusal surface and with red utility wax on the lingual cusp.

Cut an occlusal shoulder on the nonfunctional cusp with a no. 171L bur at the level of the axial termination of the functional cusp bevel (Fig 12-16). The shoulder is 1.0 mm wide and extends from the central groove on the mesial to the central groove on the distal surface. It provides space for metal to reinforce the occlusal margin on the funtional cusp.

There are two acceptable occlusal finish lines for the functional cusp of an MOD onlay: an occlusal shoulder or a heavy chamfer (Fig 12-17).[28] Both configurations provide an acute edge of gold at the cavosurface angle, with a nearby bulk of metal for strength. The shoulder with a bevel is easier to prepare properly and should be used by the novice.

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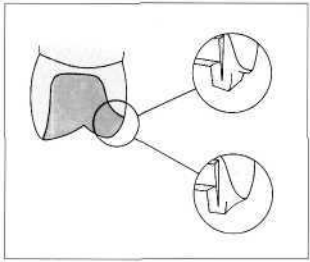


Fig 12-17 Functional cusp finish lines for MOD onlay: Occlusal shoulder *(top)* and chamfer *(bottom).* (After Ingraham.[7])

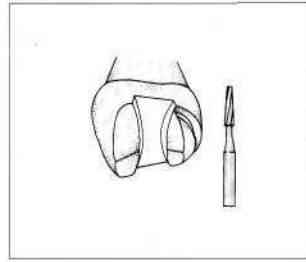


Fig 12-18 Isthmus: No. 171L bur.

The isthmus is made next with the no. 171L bur (Fig 12-18). If an old restoralion was removed earlier, the isthmus is retouched to smooth the walls and impart a minimum taper. Besides removing caries and old restorations, the isthmus reinforces the restoration. It provides some retention and a great deal of resistance.[40] Because the occlusal surface already has been reduced, the isthmus of an onlay is shallower than that of an inlay.

The no. 170L bur is used to begin the proximal boxes (Fig 12-19). If the proximal surface is intact, it is easier to start with a no. 169L bur. The walls of the boxes are carried far enough buccally and lingually to barely break contact with the adjacent teeth. The facial extension of the mesial box is usually more conservative than that of the distal box. Extensions will be finalized with a flame diamond on the flares later.

Redefine the buccoaxial and iinguoaxial line angles of each box with the no. 169L bur. Then use an enamel chisel to plane the facial and lingual walls. Flat walls perpendicular to the direction of rotating forces, not box angles, give a restoration resistance. Be sure the boxes have a common path of insertion. Smooth the pulpal floor of the isthmus, the 1,0-mm-wide occlusal shoulder on the functional cusp bevel, and the gingival floors of the proximal boxes, which are also 1.0 mm wide.

Proximal flares are added after the boxes have been formed (Fig 12-20). If the flares were cut first, facial and lingual box walls will be poorly defined, and retention will suffer. Flares are usually cut with the tip of the flame diamond, starting from within the box. A wide enamel hatchet can be used for mesiobuccal flares in areas where the cosmetic result is important.

Use a flame diamond to add a bevel 0.5 to 0.7 mm wide to the gingival cavosurface angle of each box (Fig 12-21). It provides for an acute edge of metal in these areas. The instrument is leaned against the pulpal-axial line angle to prevent the bevel from being too long and having too sharp an angle. This may round the proxtmo-occlusal line angle, which is acceptable. Blend the bevel into the facial and lingual flares without creating an undercut. Smooth the flares and gingival bevel with a flame carbide bur. This produces a sharp, distinct finish line that will facilitate marginal adaptation of the restoration.

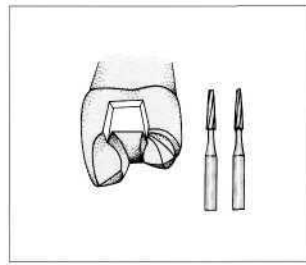


Fig 12-19 Proximal box: No. 169L and no. 170L burs.

Occlusal finishing bevels 0.5 to 0.7 mm wide are placed at the buccal and lingual occlusal finish lines with a flame diamond followed by a no. 170L carbide bur (Fig 12-22). The buccal bevel is perpendicular to the path of insertion where esthetics are important, and forms a heavier contrabevel where they are not. The bevels are blended into the respective flares. If the bevel on the

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Fig 12-20 Proximal flares: Flame diamond and flame bur.

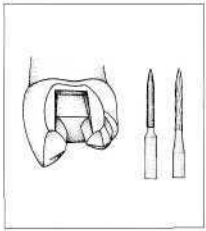


Fig 12-21 Gingival bevel: Flame diamond and flame bur.

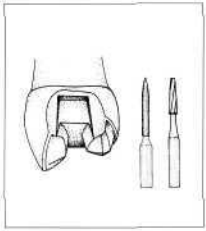


Fig 12-22 Facial and lingual bevels: Flame diamond and no. 170 bur.

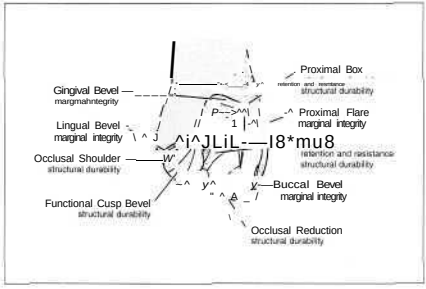


Fig 12-23 Features of a maxillary MOD onlay preparation and the function served by each.

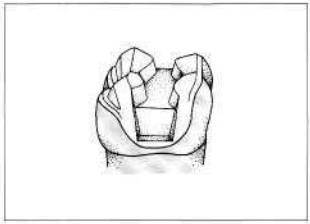


Fig 12-24 MOD onlay prep.nation on a mandibular molar.

occlusal shoulder is too wide, a thin, unsupported margin will result in the wax pattern and the casting. Figure 12-23 identifies the features of an MOD onlay preparation on a maxillary premolar and the function served by each feature.

The preparation on a mandibular molar differs from that on a maxillary tooth in that the functional cusp bevel and occlusal shoulder are located on the buccal cusp (Fig 12-24). In addition, the lingual bevel is wider and it can be a definite contrabevel, since esthetics is not a consideration on the lingual cusp of a mandibular tooth and structural durability is. These bevels should blend into the proximal flares, with the cavosurface line of the bevel continuous with the cavosurface line of the flare. There should not be a sharp occlusoproximal corner where the bevel and flare meet

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Chapter 13

Preparations for Extensively Damaged Teeth

One of the criteria for the use of a cast metal, metal-ceramic, or all-ceramic restoration is a tooth that has been damaged lo the extent that it must be reinforced and protected. It should not be surprising that unmodified classic preparation designs are used infrequently. They are applicable only on intact fixed partial denture abutments and on severely damaged teeth following the replacement of coronal bulk with an amalgam or resin core, or with a dowel core.

Most individual teeth requiring cemented restorations, as well as many fixed partial denture abutments, have been damaged enough to require modification of a classic preparation design. The amount of tooth structure destroyed is only one factor to consider in selecting a restorative material and designing a preparation. Equally important is the location of the destruction and the amount of tooth surface involved. Location can be classified as *peripheral,* occurring on the axial surfaces of the tooth; *central,* in the center of the tooth; or *combined,* with destruction in both sites.[1]

Peripheral destruction, even when it does not threaten the pulp, may require an extensive restoration such as a full crown because of the wide expanses of enamel that have been affected (Fig 13-1). A large central lesion that has undermined much of the enamel may require the placement of an amalgam core followed by a crown (Fig 13-2). However, less extensive damage in the central region, with or without proximal involvement, may be better restored with a less destructive MOD onlay that gains retention from peripheral tooth structure rather than destroying it (Fig 13-3). Combined destruction of severe dimensions may also require the placement of a core or foundation restoration followed by a crown (Fig 13-4)

Principle of Substitution

When it is necessary to compensate for mutilated or missing cusps, inadequate length, and in extreme cases even a missing clinical crown, the *principle o! substitution* is used. For those teeth with moderate to severe damage that test a dentist's ingenuity, a preparation may be modified by squaring the walls of defects left by caries and old restorations, and by adding features to enhance retention and resistance. Boxes may be substituted where grooves might ordinarily be utilized. Grooves may be used to augment retention and resistance where axial walls have been shortened. Pins may be employed where much of the supragingival tooth structure has been destroyed. More than one of these auxiliary features may be employed where damage is severe.

Two rules should be observed to avoid excessive tooth destruction while creating retention in an already weakened tooth:

1. The central "core" (the pulp and the 1,0-mm-thick surrounding layer of dentin) must not be invaded in vital teeth.[2] No retentive features should extend farther into the tooth than 1.5 mm at the cervical line or down 1.5 mm from the central fossa (Fig 13-5). If caries removal results in a deeper cavity, any part lying within the vital core should be filled with glass ionomer cement. Any preparation feature added for mechanical retention is kept in the safe area of the tooth, peripheral to the vital core.
2. No wall of dentin should be reduced to a thickness less than its height for the sake of retention. This may preclude the use of a full veneer crown, or if one must be used, it might first require the placement of a core or foundation restoration.

Box Forms

Small to moderate interproxirnal carious lesions or prior restorations can be incorporated into a preparation as a box form. This substitute for grooves serves the dual purpose of caries removal and retention form[3-5] (Fig 13-6). Because large quantities of tooth structure must be removed for it, the box is not usually used on an intact surface.

Opposing upright surfaces of tooth structure adjacent to a damaged area can be used to create a box form if at least half the circumference (180 degrees) remains in the area outside the lingual walls of the boxes. The walls of the box, and not the line angles, will resist displacements If the mesial and distal surfaces are extensively

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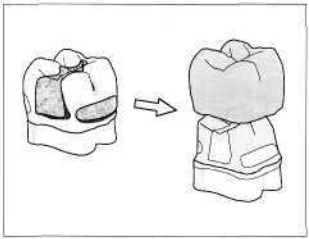


Fig 13-1 Teeth with large areas of enamel involvement may require full-coverage restorations regardless of the amount of dentin that has been destroyed.

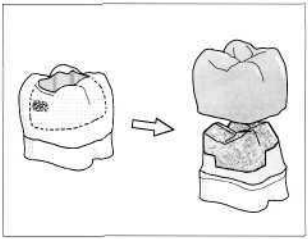


Fig 13-2 A large central lesion may require a full-coverage restoration, but only after the tooth is built up with a core.

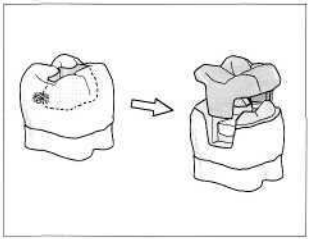


Fig 13-3 Moderate central damage can be restored with a restoration that preserves and uses sound peripheral tooth structure rather than destroying it.

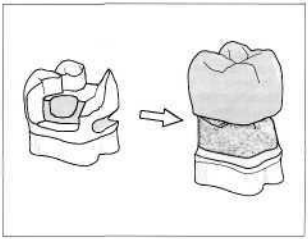


Fig 13-4 Severe combined destruction will require a core and a full-coverage restoration.

involved, another means must be used to compensate for the diminished lingual tooth structure (Fig 13-7). This situation may require a crown placed over a pin-retained amalgam core.

Grooves

Grooves placed in vertical walls of bulk tooth structure must be well formed, at least 1.0 mm wide and deep, and as long as possible to improve retention and resistance. Multiple grooves are as effective as box forms in providing resistance,[7] and they can be placed in axial walls without excessive destruction of tooth structure. They may also be added to the angles of oversized box forms to augment the resistance provided by the box walls. This is particularly helpful when the facial and lingual walls of a box are a considerable distance apart. However, too many grooves in a crown preparation can adversely affect the seating of a full veneer crown.s

Pins

Pins effectively increase retention[9,""] by generating additional length internally and apically rather than externally" They do not require vertical, supragingival tooth structure for their placement, and they can be used where there is insufficient axial wall length. They can extend apically beyond the gingival attachment without harming it.

Pins are commonly used in two ways: *(1)* Pin holes parallel the path of insertion of the preparation, receiving

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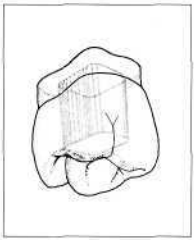


Fig 13-5 No retentive features may be cut into the "vital core" of the tooth (center).

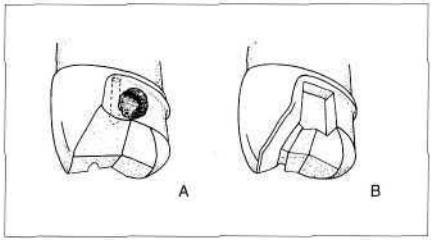


Fig 13-6 Interproximal caries may preempt the use of a groove *(dotted line)* (A). Use of a box in this situation accommodates caries removal and provides retention (B).

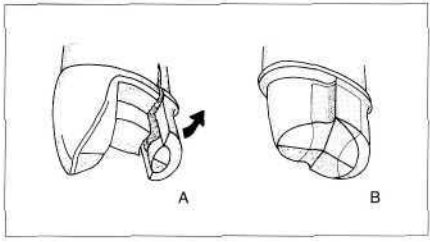


Fig 13-7 If significantly less than 180 degrees of the tooth's circumference remains between two boxes, the lingual cusp is susceptible to fracture during function, upon removal of the provisional restoration, or at try-in of the permanent restoration (A). A core with a different preparation design will minimize the risk of fracture and provide better longevity for the crown (B).

pins that are an integral part of the cast restoration (Fig 13-8, A), or *(2)* nonparallel pins are placed in the tooth to retain an amalgam or composite resin core in which a classic preparation for a cast restoration can be formed (Fig 13-8, B).

Careful pin hole placement is critical for restoration success. Four guidelines should be followed in drilling pin holes[12]:

1. Place them in sound dentin.
2. Do not undermine enamel.
3. Avoid perforation into the periodontal membrane.
4. Do not encroach upon the pulp.

Pin holes should be placed vertically in shoulders or ledges halfway between the outer surface of the tooth and the pulp, surrounded by at least 0.5 mm of dentin.[13] The safest locations for pin holes are the line angles or corners of the teeth (Fig 13-9). "> The least desirable area for placing pin holes is midway between the corners,[14] especially in regions overlying the furcations.[15]

To avoid problems, the location and direction of the drill must be carefully controlled. After studying a radiograph, gently place a probe,[14] or the drill itself,[16] into the gingival sulcus, against the side of the tooth, to get a clear picture of the direction of the outer tooth surface in the area of the pin hole. This limits the use of parallel pins that are part of the casting, because the preparation path of insertion may dictate a pin direction that could cause pulpal or periodontal complications.

If bleeding occurs while drilling a pin hole, determine whether the misdirected drill has gone into the pulp or the periodontal membrane. If it is in the pulp, perform endodontic therapy before proceeding. If the hole exits the root surface, measure the pin before insertion so that

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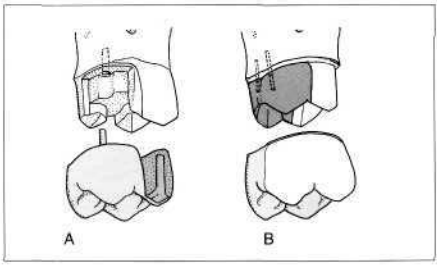


Fig 13-8 A pin can be incorporated into a crown to augment retention and resistance (A); or pins can be used to retain a core, which in turn will help to retain a crown (B).

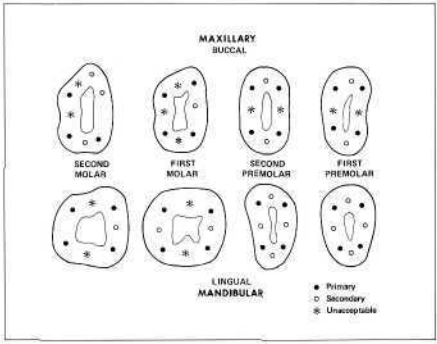


Fig 13-9 Areas for the placement of retentive pin holes in posterior teeth (after Fisher).

it neither overfills nor underfills the hole. Healing is then possible, although not guaranteed. A pin that extends into the periodontium coronal to the alveolar crest should be exposed with a surgical flap and trimmed flush with the root surface.

The technique used for placing the pin holes and reproducing them in the impression is that described by Shooshan.[17] It uses a 0.6-mm (0.024-inch) drill to cut the pin hole, a nylon bristle to reproduce the pin hole in the impression, and a nylon bristle or indioplatinum pin to produce a pin in the restoration. The pin hole is countersunk slightly to form a funnel-shaped opening. This strengthens the pin where it joins the casting[18] and guides the pin into the hole during seating.

Although retention increases as the number, depth, and diameter of pins increases,[1930] a point of diminishing returns occurs after four or five pins are placed.[21] This experimental finding confirms the clinical recommendations that one pin should be used for each missing cusp,[22] line angle,[23] or axial wall.[24] Self-threading pins are nearly five times more retentive than cemented pins and need be placed to a depth of only 2 0 mm. However, cemented pins that are an integral part of the restoration need to extend 4.0 mm into the tooth.[25]

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Bases and Cores

When Ihe destruction of tooth structure is more extensive, a decision must be made whether to augment the retention and resistance by adding auxiliary features or to build up the tooth preparation with a pin-retained core (Fig 13-10).

Bases

Cement bases are used only to protect the pulp and to eliminate undercuts in defects in tooth structure produced by the removal of caries or old restorations. They are used if there is adequate bulk of tooth structure to resist occlusal forces and enough axial wall surface to provide retention for the final restoration.

Glass ionomer and polycarboxylate cements are excellent materials for this purpose. They are nonirritating to the pulp and have some adhesive properties that make them less likely to become dislodged during subsequent preparation of the tooth. Deep areas of the preparation near the pulp may be covered with calcium hydroxide. Cement bases do not have sufficient strength to effectively replace weakened dentinal walls, unless there are two walls of tooth structure remaining.[28] Amalgam or composite resin should be used for that purpose.

An undercut left by caries removal often can be eliminated by creating a box, if the additional retention is needed. However, if creation of a box will destory excessive sound tooth structure, it is better to fill the defect with cement. If the defect is very close to a finish line, amalgam should be used because it is strong and insoluble.

Cores

If half or more of the clinical crown has been destroyed, an amalgam or composite resin core should be placed in the tooth. The core is then treated as though it were tooth structure, and a classic full veneer preparation is used. If less than half of a clinical crown has been destroyed, a preparation design that will empioy auxiliary features for added retention in the area of missing cusps can be used.

All cusps thinner than half their height should be shortened or removed. Cavity floors and walls are flattened for increased resistance, taking care not to traumatize the pulp or weaken the remaining walls. A core must be anchored firmly to the tooth and not just placed to fill the void. Otherwise, it offers no advantage over allowing the bulk of the casting to occupy the space.

Pin-retained cores have been utilized to retain cast restorations on severely damaged teeth for nearly 40 years,[1&S7,M] Both amalgam and composite resin have been used for this purpose. Composite resins are favored by some because they are easily molded into large cavities and they polymerize quickly, allowing the crown preparation to be done at the same appointment.

However, composite resin cores exhibit greater microleakage than do amalgam cores,[29] and they are not as dimensionally stable as amalgam. In an in vitro study, crowns made for teeth with composite resin cores failed to seat by 226 um more than crowns made for teeth with amalgam cores after immersion in body-temperature normal saline solution for 1 week.[30] The surface of a composite resin core is affected adversely by exposure to zinc oxide-eugenol temporary cement,[31] although that does not seem to have a negative effect on the tensile strength of the final crown.[32]

Single-phase, copper-rich amalgams attain sufficient hardness to allow a crown preparation to be made after only 10 minutes.[33] Retention devices other than pins can be used for amalgam cores. Slots that are the width and depth of a no. 337a bur can be placed around the periphery of the preparation.[34] "Dentin chambers," or pot holes, 2 to 3 mm deep can be placed with no. 1156, 1157, or 1158 burs. When amalgam is condensed into these holes, they become "amalgapins."[35]

Retentive features for the core must be deep enough not to be removed by the axial reduction done in the crown preparation. A properly contoured amalgam core can serve as a temporary restoration for several weeks, giving the tissue an opportunity to recover while more urgent treatment is being performed.

The preparation finish line for the cast restoration should extend beyond the core into tooth structure.[30] The farther the core extends subgingivally, the more likely it is to have voids and overhangs that will make it unsuitable to remain exposed beyond the margin of the final restoration. If the core is amalgam, dissimilar metals in contact with it are more prone to corrosion when exposed to the oral environment. If the core is composite resin, it is susceptible to leakage.

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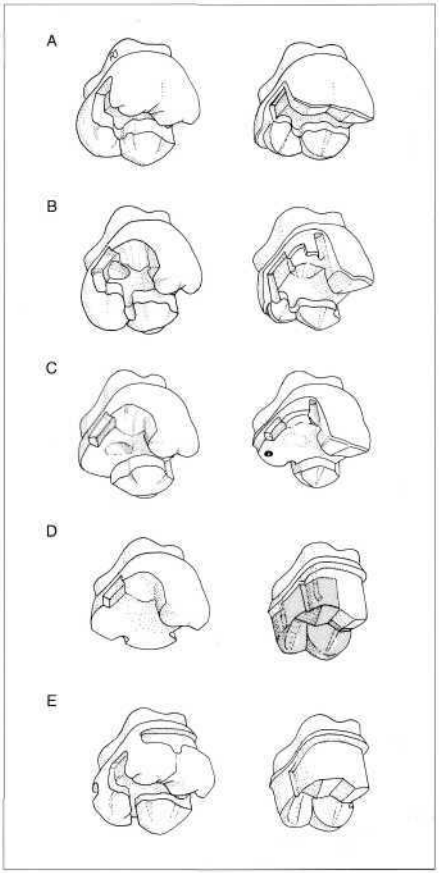


Fig 13-10 If the tooth to be prepared for a cast restoration has been only moderately damaged (eg, an old MOD amaigam), a standard MOD onlay preparation or a three-quarter crown preparation with boxes can be used (A). If one cusp has been destroyed, a widened box with groove augmentation can be used (B). When half of the crown has been destroyed, grooves may provide sufficient retention if the supragingival tooth structure in which they are placed has sufficient length. Pin holes may be added to the preparation (Q. If three or more cusps have been destroyed, a pin-retained core should be fabricated before proceeding to a full-coverage cast restoration (D). Extensive peripheral destruction often requires a full-coverage cast restoration if caries has been controlled (E).

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Modifications for Damaged Vital Teeth

In preparing a damaged tooth (Fig 13-11, A), follow an orderly sequence to lake full advantage of remaining tooth structure to attain the most retentive preparation possible.

1. *Evaluate pulpai health.* If it is questionable, or if there is an exposure, however small, endodontic therapy should be done before placing a cast restoration.[37] Otherwise, the restoration later may be compromised by the endodontic access. Nonetheless, make every effort to maintain the vitality of the pulp. Endodontic treatment is usually successful, but nothing is perfect. Even if it is successful, it weakens the tooth and increases the cost of restoring it.
2. Assess *the periodontal condition.* Examine penodontal tissues for deep subgingival extensions of caries, fractures, or previous restorations. Finish line extensions that violate the "biologic width" of 2.0 mm of tissue attachment may require periodontal surgery before a restoration is made.[38-36]
3. *Make a preliminary preparation design.* A general concept can be formulated beforehand, but the specific features to be used and their location cannot be ascertained until the initial phases of the preparation have been completed.
4. *Remove previous restorations and bases, all caries, and any unsupported enamel* (Fig 13-11, B). Even if an existing restoration appears sound, it may conceal caries or a pulp exposure. Remove it. Concave, roughened areas from which caries and previous restorations have been removed, or sloping surfaces remaining after cuspal fracture, must be oriented to enhance resistance and retention. They should be formed into vertical and horizontal components, or steps, with essentially vertical surfaces made parallel with the path of insertion (Fig 13-11, C). They must be kept at the periphery of the preparation, with gmgival shoulders and floors no wider than 1.5 mm. Horizontal surfaces are made perpendicular to the path of insertion to increase resistance to occlusal forces (Fig 13-11, D). No flat horizontal surface in the central portion of the tooth should be any deeper than the level of the pulpai floor of a classic isthmus.
5. *Evaluate the strength of the remaining walls.* Decide whether to incorporate remaining defects into the preparation or to fill them in. If more than 50% of the coronal tooth structure of a posterior tooth is sound, and the tooth will not be an abutment, sufficient retention can be achieved by adding supplemental features to the preparation. Internal features such as isthmuses or box forms must have surrounding walls of dentin that are at least as wide as they are high. If the thickness-to-height ratio of a wall lies between 1 • 1 and 1:2. it should be supported. Any wall with a thickness-to-height ratio of less than 1:2 is subject to fracture and should be shortened.
6. *Finalize the preparation design.* Begin with occlusal reduction (Fig 13-11, D) and then proceed with axial reduction (Fig 13-11, E). With abase, fill in the central areas of the tooth that were too deep to be included in the orientation of horizontal and vertical surfaces. Do not bother to mold a large bulk of base to a classic preparation configuration, since no retention is gained from a cement base.

The preparation is ready for the placement of its retention features. Only after all other portions of the preparation are complete can a decision be made about the type, number, and location of retentive features that will be used. The preparation is completed by their addition (Fig 13-11, F).

Placement of grooves, pin holes, and box walls in a base is the same as not using them at all (Fig 13-12, A). Retention and resistance forms must be placed in solid tooth structure, not in base, if they are to provide any resistance to dislodgment (Fig 13-12, B). Since retentive features can be formed no more than 1.5 mm from the outer surface of the tooth, deep destruction of tooth structure requires that the axial wall of a box be placed in a nonretentive base rather than in dentin. If the buccal and lingual walls are in dentin, the box will provide significant retention. The danger to the pulp from extending the box closer to the pulp would be an unacceptable risk for the little retention that might be added.

An important aspect of restoring damaged teeth is the protection of remaining tooth structure. Teeth already weakened by the loss of large amounts of tooth structure are ill-equipped to withstand occlusal forces unassisted. Protection can be provided by capping cusps with the cast restoration.[4041] The occlusal thickness in metal should be 1.0 mm over the nonfunctional cusps and 1.5 mm over the functional cusps.

The choices for anterior teeth are more limited because of esthetic requirements and the smaller bulk of dentin in which supplemental features can be placed. Modifications of classic anterior preparations are limited to substitution of a box for a groove to encompass a carious lesion, or addition of extra grooves or pin holes. If more than one-third of the coronal structure is lost, placement of a pin-retained core followed by a metal-ceramic crown is usually indicated.

There will be times when it is necessary to devitalize a tooth to obtain retention. If a crown is to be placed on a narrow, single-rooted tooth with little or no coronal tooth structure, a core may not have sufficient resistance to dislodgment without a dowel that extends into the root.

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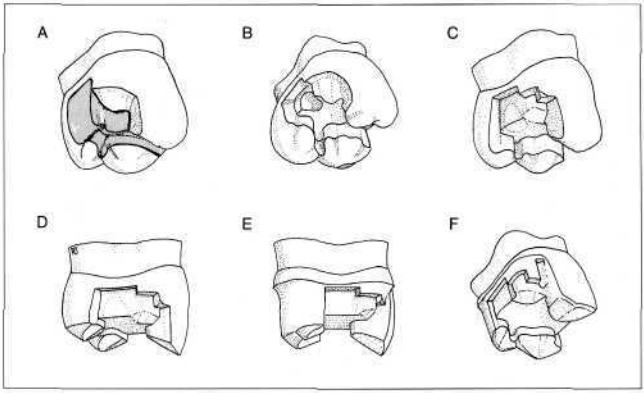


Fig 13-11 Maxillary molar with a missing distohuccal cusp and a defective MOD amalgam (A). All caries, previous restorations, bases, and undermined enamel are removed (B). Steps are formed in sloping areas with vertical surfaces made parallel with the path of insertion and horizontal surfaces perpendicular to it (C). Occlusal reduction (D) and axial reduction (E) are done on the remaining tooth structure. Addition or refinement of auxiliary retention features completes the preparation (F).

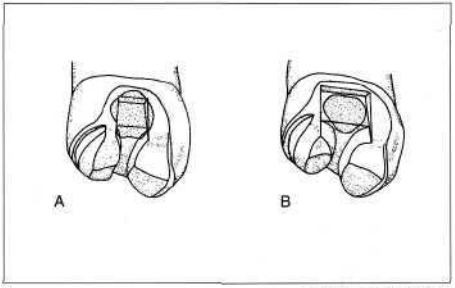


Fig 13-12 A box placed in cement (A) will not provide retention and resistance. If the box is widened buccolingually and lengthened gingivafly so that the facial and lingual walls are in solid tooth structure, retention will be improved (B).

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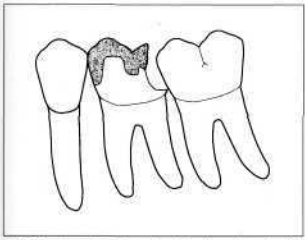


Fig 13-13 Second molar has migrated into the void produced by caries.

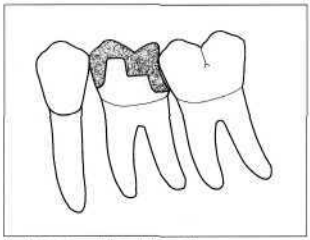


Fig 13-14 The tooth is first built up with a core.

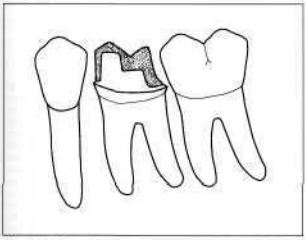


Fig 13-15 The tooth and core are prepared for a full veneer crown.

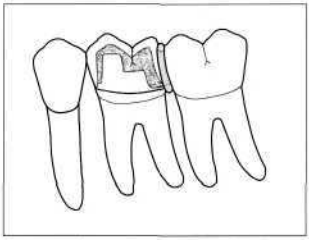


Fig 13-16 An elastic separator creates the initial space between the provisional crown and the adjacent tooth.

Orthodontic Adjuncts to Restoring Damaged Teeth

Caries or irauma may produce tooth destruction of a magnitude or in a location that makes it difficult or impossible to restore the tooth without serious esthetic or periodontal compromise. Simple orthodontic procedures can be employed in some of these situations to make it possible to restore the teeth in a manner that will improve the prognosis for long-term success and provide a more pleasing esthetic result where required.

Regaining Interproximal Space

A long-standing carious lesion on the proximal surface of a molar often will result in migration of the adjacent molar into the void created by the caries (Fig 13-13). It is not enough just to excavate the caries and place a restoration in such a situation. The teeth frequently contact at, or apical to, the cementoenamel junction. Simply placing a restoration in these circumstances would result in a concave proximal contour and a closed embrasure space that would wreak havoc on the periodontium. Instead, the space should be regained by separating the teeth with the brass wire technique described by Reagan.[42]

A core or foundation restoration is placed in the tooth requiring restoration (Fig 13-14) and then it is prepared for a full crown (Fig 13-15). An acrylic resin provisional crown is fabricated using the technique described in

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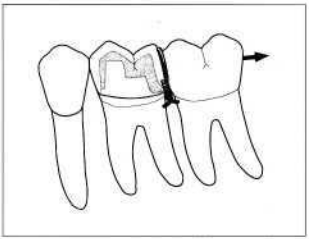


Fig 13-17 Brass wire is wrapped around the contact and twisled to further separate the teeth.

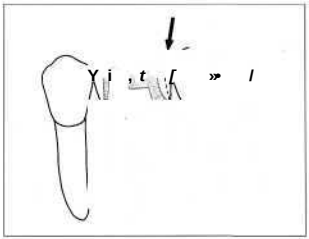


Fig 13-18 Hie contact is closed by adding resin to the dislal aspect of the provisional restoration *(arrow).*

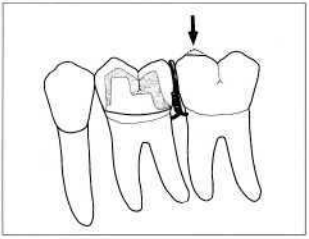


Fig 13-19 The occlusion is adjusted to allow the tooth to continue moving distally (arrow).

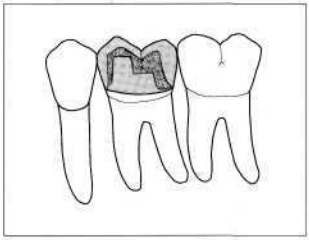


Fig 13-20 Treatment is completed by fabrication and cementation of the final crown.

Chapter 15. After adjusting and polishing the provisional crown, it is cemented. An elastic orthodontic separator is inserted into the proximal surface to initiate the movement of the adjacent tooth (Fig 13-16).

At a subsequent appointment, the elastic is removed and a piece of 0.6-mm (0.025-inch) brass wire is threaded between the teeth from the facial side, apical to the contact. The wire is wrapped around the contact, bringing the two ends together on the facial side. There the wire is twisted together until the patient feels pressure. The twisted end of the wire is cut off, leaving a 5- to 6-mm tail. The cut end is bent over so that it will not stab the patient's cheek (Fig 13-17),

At approximately 1-week intervals, the wire is tightened by twisting until the tooth shows no movement from the previous appointment. At this point the provisional restoration is removed and the crown is built back into contact with the adjacent tooth by adding acrylic resin (Fig 13-18). The crown is repolished and recemented, and the brass wire is reapplied. As the adjacent tooth is tipped distally, it may move upward into the occlusal plane. If it does, adjust it occlusally to permit it to continue to move distally (Fig 13-19).

Caries extensive enough to require orthodontic movement often extends far enough apically that some type of surgical crown-lengthening procedure will be required. This will not only facilitate successful completion of the crown, but it will also prevent subsequent periodontal inflammation around the crown margin. Then the full crown that will serve as the final restoration is fabricated and cemented (Fig 13-20).

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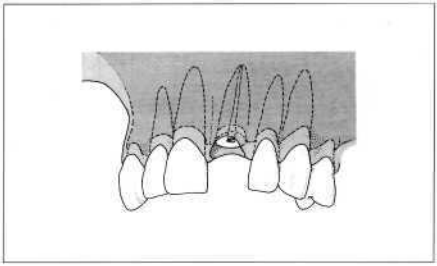


Fig 13-21 This central incisor is fractured to the level of the alveolar crest.

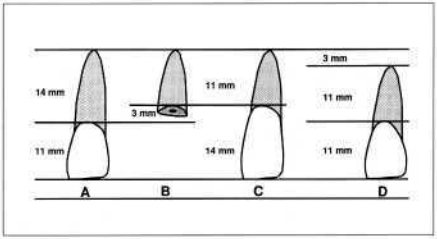


Fig 13-22 Extrusion vs surgical crown lengthening. The normal anatomic crown-root ratio for an average central incisor is 11:14 (A). In this example, the tooth is fractured 3.0 mm beyond the cementoenamel junction (B). Surgical crown lengthening alone would produce an unstable and unesthetic crown-root ratio of 14:11 (C). Extrusion followed by crown lengthening produces a more stable crown-root ratio of 11:11 with a more esthetic, normal crown length (D).

Extrusion of Teeth

When all tooth structure has been lost to the level of the alveolar crest or beyond, because of either fracture or caries, the tooth cannot be satisfactorily restored without some extraordinary measure (Fig 13-21). Even if a dowel core is placed in the tooth, the root will remain susceptible to fracture without the crown encircling the tooth apical to the core. This *ferrule effect* around the tooth protects it from fracture by the dowel from within.[35] In fact, if tooth structure is lost "only" to the level of the epithelial attachment, minor extrusion may be desirable to permit access to enough tooth structure apical to the finish line to produce a ferrule effect.

Burying the finish line subgingivally will not solve the problem. Rather, it will create new ones: the increased possibility of an ill-fitting crown and placement of the margin in an area that would violate the "biologic width" of soft tissue attachment. This particular problem can be overcome by surgical crown lengthening alone, but the result will be most unesthetic. Surgery shortens the root and also increases the crown-root ratio (Fig 13-22).

Orthodontic extrusion has been used to move solid root structure into an accessible area.[43] The use of orthodontic brackets has been described for this purpose.[44-47] However, they are bulky and unesthetic, and they may be difficult to place far enough apically to permit sufficient space for extrusion. Furthermore, their use may cause unwanted movement of the abutment teeth.[48] Removable appliances also can be used to extrude teeth,[49] but they require a high degree of patient compliance. The technique presented below utilizes an anchorage wire bonded to adjacent teeth as described by Oesterle and Wood.[48]

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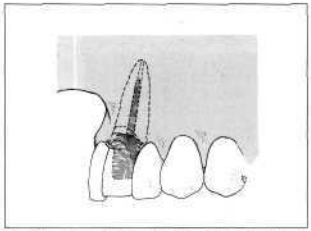


Fig 13-23 A bent pin is placed in the gingival area of the facial surface of the provisional crown.

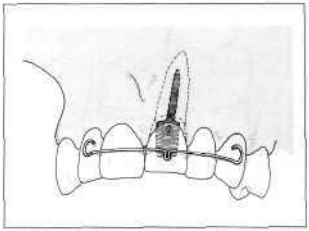


Fig 13-24 Arch wire extends two teeth on either side of the tooth to he extruded. There is a loop in the wire over both terminal abutments, to aid retention by resin, and a loop in the middle o-ver the tooth to be extruded.

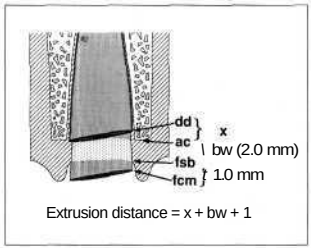


Fig 13-25 The amount of extrusion needed is determined by adding the distance the destruction extends beyond the alveolar crest, the biologic width of 2.0 mm, and 1.0 mm between the bottom of the sulcus and the crown margin. If the destruction extends 1.0 mm beyond the alveolar crest, 4.0 mm of extrusion would be necessary, ac = alveolar crest, bw = biologic width, dd = deepest extent of destruction, fcm = final crown margin, and fsb = final bottom of sulcus.

The tooth first must be endodontically treated. The extrusion can be done with either a permanent or a temporary dowel core in the tooth. In either case, place a provisional crown on the tooth to be extruded. This maintains space and provides an esthetic appearance during treatment. If the permanent dowel core is fabricated before extrusion, make it at least 3.0 mm short of its normal incisal length to allow space for extrusion.

Embed a TMS pin (Coltene-Whaledent, New York, NY) in the mesiodistal center of the facial surface of the provisional crown, as near the gingiva as possible. The pin is either directed slightly gingivally or bent to facilitate retention of the elastic that will be placed on it later (Fig 13-23).

Bend a facial 0.018 x 0.025-inch stainless steel orthodontic arch wire, with a small loop opposite the middle of the tooth to be extruded. The loop, an attachment for the elastic, is bent in an incisal direction to prevent the elastic from slipping off. The base of the loop should touch the facial surface of the tooth to prevent the tooth from moving lingually as it erupts. The arch wire should extend for two teeth on either side of the tooth to be extruded with a loop in each end of the wire for retention (Fig 13-24). The use of this number of abutments minimizes the possibility of moving them rather than the intended tooth.

Place the arch wire at the incisogingival level to which the TMS pin will be moved, equaling the amount of extrusion to be accomplished. The distance that the tooth is to be extruded is calculated by adding *(1)* the distance from the most apical point of fracture or caries to the alveolar crest (if the damage extends subcrestally): *(2)* 2.0 mm for the biologic width^; and *(3) at* least 1.0 mm to prevent placement of the crown margin too far subgingivally (Fig 13-25). If the damage is flush with the alveolar crest, a minimum of 3.0 mm of extrusion would be required.[48]

Affix the arch wire to each of the four abutment teeth, using a light-activated resin. Create an occlusal clearance of 1 .0 mm on the provisional crown, and attach an elastic to the pin on the crown and the loop on the wire (Fig 13-26) . Check the patient weekly.[15] The tooth will elongate at a rate of 1.0 to 1.5 mm per week.[44,118,49] Relieve the occlusion again and replace the elastic.

When the TMS anchorage pin in the facial surface of the provisional crown is even with the arch wire, the extrusion is completed. Remove the elastic and replace it with a ligature wire, tying the pin on the crown to the loop in the arch wire (Fig 13-27). Check the occlusion to

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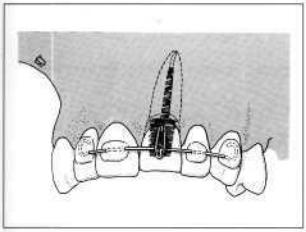


Fig 13-26 An elastic extends from the pin on the crown to the loop in the arch wire.

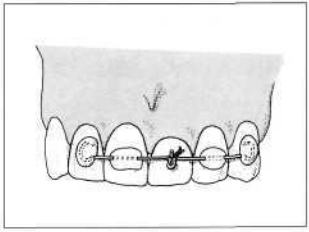


Fig 13-27 When ibe tooth has been extruded so that the pin on the crown contacts the loop in the arch wire, it should be stabilized with ligature wire. The descended level of the gingiva makes the clinical crown shorter.

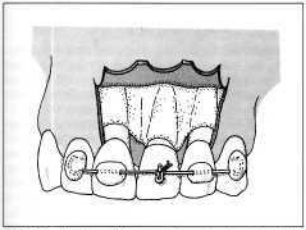


Fig 13-28 An elevated flap reveals that the alveolar level has descended with the tooth.

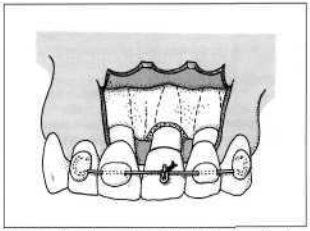


Fig 13-29 Bone is removed to the level of the adjacent teeth.

insure that there are no interferences. Traumatic occlusal contacts will interfere with healing and stabilization of the tooth. The teeth should remain ligated for at least 1 month before proceeding lo the next phase of the treatment ^

The alveoiar bone and gingival attachment frequently will descend with the tooth (Fig 13-28). If there was a pre-existing periodontal defect, it may be lessened or eliminated.'t50-52 However, if the periodontium was normal before the extrusion was undertaken, surgery may be necessary to bring the levels of the bone and the gingival crest into line with those of the adjacent teeth.[48]^^ A flap is reflected over the extruded tooth, and bone is removed to match the osseous level of the adjacent teeth (Fig 13-29). The final restoration can be started approximately 4 weeks after the surgery (Fig 13-30).[48]

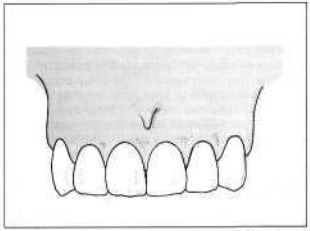


Fig 13-30 Final restoration on a tooth with a clinical crown whose length is similar to that of the adjacent teeth.

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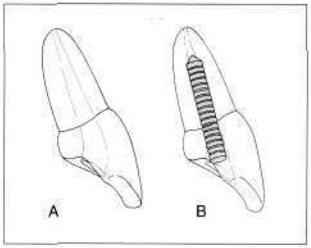


Fig 13-31 A tooth with an intact clinical crown can be adequately restored with composite resin (A). A dowel provides unnecessary "reinforcement" that may weaken the tooth instead (B). (From Shillingburg and Kessler.)

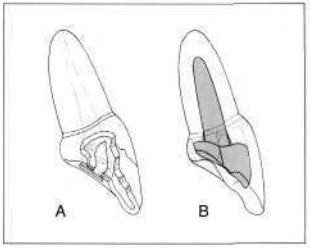


Fig 13-32 A single-rooted pulpless tooth with a severely damaged crown (A) usually will require a dowel core before placement of a crown (B). (From Shillingburg and Kessler.[58])

Restoration of Endodontically Treated Teeth

The restoration to be used on an endodontically treated tooth is dictated by the extent of coronal destruction and by the type of tooth. Traditionally, a pulpless tooth received a dowel to "reinforce" it and a crown to "protect" it. Retrospective clinical surveys in recent years have caused a reappraisal of this thinking. In a study of 220 endodontically treated teeth, Ross[55] found that nearly 61% of the teeth that had been in service for 5 years or longer had not been restored with dowels. Sorensen and Martinoff[56] reported almost identical success rates for endodontically treated anterior teeth restored with and without dowels.

Rationale

In that same study by Sorensen and Martinoff,[55] there also was no significant difference between the success achieved with anterior pulpless teeth that had received crowns and those that had not. It is then obvious that endodontically treated anterior teeth do not automatically require crowns.[57-59] If a moderately sized anterior tooth is intact except for the endodontic access and one or two small proximal lesions, composite resin restorations will suffice. Placement of a dowel in such a tooth is more likely to weaken it than to strengthen it (Fig 13-31).

Lovdahl and Nicholls[60] found that intact endodontically treated central incisors were three times as resistant to fracture as teeth that had been restored with dowel cores.

For a tooth that has become discolored following devitalization, bleaching is preferable to crown placement if the tooth is relatively intact.[67] A laminate veneer offers a less destructive alternative if the facial surface of a reasonably intact tooth must be masked by a restoration.

However, the axial reduction for a crown preparation (peripheral destruction) combined with an endodontic access preparation (central destruction) frequently leaves insufficient sound dentin to support a crown unaided. If a metal-ceramic crown is required because of extensive coronal destruction, a *dowel core* probably is needed (Fig 13-32). A dowel is placed to provide the retention for a crown that ordinarily would have been gained from coronal tooth structure.[61-66] The use of a dowel requires that the canal be obturated with gutta-percha. It is difficult to ream out a canal filled with a silver point or other hard material. Lateral perforation of the root becomes a distinct possibility. If a dowel is used, its extension into the root must at least equal the length of the crown for optimum stress distribution[63] and maximum retention, or the dowel should be two-thirds the length of the root, whichever is greater (Fig 13-33). A minimum length of 4.0 mm of gutta-percha, and more if possible, should remain at the apex to prevent dislodgment and subsequent leakage. If it is not possible to meet these criteria, the prognosis for the restoration will be compromised and some alternative should be explored.

The longer a dowel, the greater its retention.[64,67] A tooth with a dowel that is three-quarters the length of the crown or shorter has less chance for success than a tooth that has no dowel at all.[65] However, the success rate of dowel-treated teeth can increase to more than 97.5% when dowel length equals or exceeds the length of the crown.[68]

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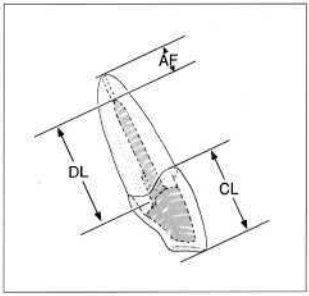


Fig 13-33 The length of the dowel (DU should equal the crown length (CL) or two-thirds the length of the root, whichever is greater. The length of the remaining apical fill IAF) should be at least 4.0 mm.

Posterior teeth must be treated differently. Because of their naturally divided occlusal surface, even caries-free teeth can fracture vertically under occlusal forces. The minimum treatment indicated for an endodontically treated molar or premolar is the placement of a cast restoration with occlusal coverage, such as an MOD onlay.[69] Sorensen and Martinoff[68] found that 94% of endodontically treated molars and premolars that subsequently received coronal coverage were successful, while only 56% of occlusally unprotected endodontically treated posterior teeth survived.

Those endodontically treated posterior teeth with sufficient sound tooth structure to be restored with an MOD onlay are in a distinct minority. Many teeth that require endodontic therapy have been so damaged by caries, previous restorations, and the endodontic access, that limited coronal tooth structure remains to be used for retaining the final restoration.

Frequently a core must be substituted for the supragingival axial walls and auxiliary features that are customarily used. Maxillary premolars often have drastically tapering roots, thin root walls, and proximal root concavities or invaginations, all of which are predisposing factors to perforation or fracture.[70] In a study of 468 teeth that had fractured in vivo, 78% were premolars, with 62% being maxillary premolars.[71] A dowel core should be utilized on premolars only if the roots are adequately long, bulky, and straight (Fig 13-34).

Care must be exercised in the selection of restorations for teeth that have no remaining coronal tooth structure. The encirclement of 1.0 to 2.0 mm of vertical axial tooth structure within the walls of a crown creates a ferrule effect around the tooth to protect it from fracture (Fig 13-35).^ If the crown margin is not placed onto solid tooth structure, the risk of root fracture is greatly increased (Fig 13-36). Orthodontic extrusion and crown lengthening surgery may be needed to prevent encroachment on periodontal tissues (Fig 13-37).

Rosen[72] advocated a subgingival collar to act as an extracoronal brace. Hoag and Dwyer[73] determined that the type of dowel core was not as important as the presence of a full crown with margins that extended beyond the core. Having 1.0 mm of vertical tooth wall between the margin of the core and the shoulder of the preparation was found by Sorensen and Engleman[74] to provide a ferrule effect, enhancing fracture resistance by 80% to 139%. Milot and Stein's demonstrated that a steep,1.0-mm-wide bevel that is nearly parallel with the long axis of the preparation also strengthens the tooth against fracture.

If a minimum of 1.0 mm of vertical axial wall cannot be covered by a crown on a premolar that is to serve as an abutment, the tooth should be extracted. Endodontically treated teeth should not be used as abutments for distal extension removable partial dentures.[76] They are more than four times as likely to fail than pulpless teeth not serving as abutments.[77] Pulpless fixed partial denture abutment teeth fail nearly twice as often as single teeth.

Even with a ferrule effect, it is questionable whether a pulpless tooth should be used as an abutment for a fixed partial denture with a span longer than one pontic. The tooth is structurally compromised and susceptible to fracture if overloaded. The more extensive the restoration required for an endodontically treated tooth, the more time-consuming and technique-sensitive the restoration will be.[79] If a fixed partial denture must be used in such circumstances, strong consideration should be given to the use of an implant-supported prosthesis

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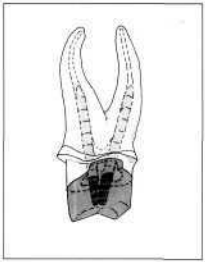


Fig 13-34 Roots of a premolar require bulk and length for the successful use of a dowel core. Both canals of a two-canal tooth are used if possible.

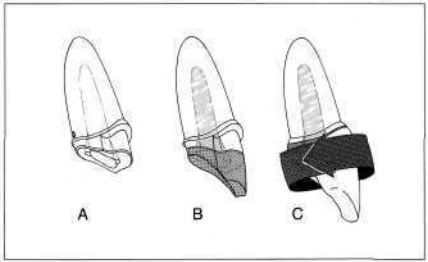


Fig 13-35 The preparation for a dowel core should preserve solid tooth structure (A). The crown preparation finish line should be apical to the dowel-core margin (B), enabling the crown to girdle the tooth *(arrow)* and brace it externally (C). (From Shillingburg and Kessler.[58])

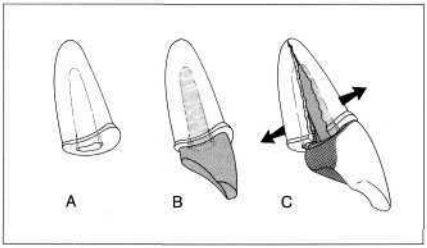


Fig 13-36 If a tooth is flush with the gingiva (A), fabrication of a dowel core and a crown without encirclement of tooth structure by the crown walls (B) could result in root fracture (C). (From Shillingburg and Kessler.[58])

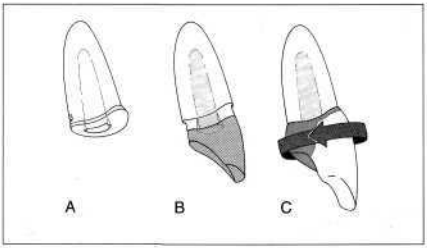


Fig 13-37 A tooth without coronal tooth structure (A) can be protected by moving the crown preparation finish line apically (B) to brace the tooth *(arrow)* against root fracture (C). (From Shillingburg and Kessler.[58])

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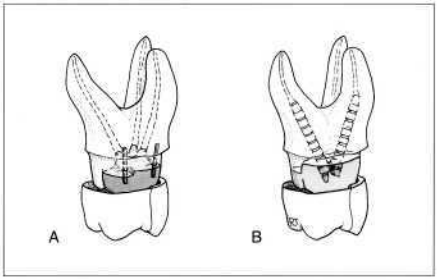


Fig 13-38 A core teiained by pins, slots, amalgapins, or extension into the pulp chamber is used to build up a molar with some coronal tooth structure (A). However, if there is insufficient coronal tooth structure to support the core, two dowels are added for retentante (B).

A pulpless molar with a moderately damaged clinical crown can be built up with an amalgam or composite resin core prior to placement of an artificial crown (Fig 13-38, A). If there is one sound cusp, the core may be retained by gross extension of the amalgam into the pulpal chamber alone,[79] or in conjunction with pins,[80] peripheral slots,[34] or dentinal wells (amaigapins).[35] A variation, usually employing two dowels, is used for motars that have little or no remaining coronal tooth structure (Fig 13-38, B).

The core and its attachment(s) are made separately from the final restoration. The crown is then fabricated and cemented over the core just as a restoration would be placed over a preparation done in tooth structure. This two-unit system offers several advantages over a one-piece dowel crown. The marginal adaptation and fit of the restoration are independent of any dowel that must be used The restoration can be replaced at some future time, if necessary, without disturbing the dowel core. If a dowel is necessary, the choice is not limited to a custom cast device Prefabricated systems can be used if the dowel does not have to be incorporated into the crown. If the endodontically treated tooth must serve as a fixed partial denture abutment, it is not necessary to make the root canal preparation parallel with the path of insertion of other preparations.

Prefabricated Dowel With Amalgam or Resin Core

Numerous techniques have been described for the fabrication of dowel cores. Prefabricated dowels with amalgam or composite resin cores are the most commonly used dowel cores today, and there is a wide variety of dowel systems available. Kits for prefabricated dowels utilize special reamers or drills for canal preparations that are the same size and configuration as the dowels. Through the use of one of these systems, it is possible to complete the entire procedure in a single appointment.[81]

Amalgam provides greater strength. Kovarik et al[62] found that 67% of the amalgam cores tested in an in vitro study survived 1,000,000 cycles of 75-lb loading, while only 17% of the composite resin cores survived. In that same study, all of the glass Ionomer cores had failed within the first 220,000 cycles. Composite resin remains popular because it is easily placed, polymerizing in minutes and allowing work on the core preparation to progress almost immediately. Resin requires less bulk of material than does amalgam, which makes it useful on small teeth.

A dowel increases resistance to lateral forces applied to the crown from 15%[83] to 48%.[84] Dowels can be made of stainless steel, titanium, brass, or a chromium-containing alloy. The preferred materials in light of current knowledge of galvanism and corrosion are titanium, high platinum, and cobalt-chromium-molybdenum alloys[85] The least desirable are brass and chromium-nickel steel.[95] Prefabricated dowels are made in both parallel-sided and tapered configurations.

Dowel systems can be classified by their mechanism of retention: *passive* (cemented) or *active* (threaded). The threaded dowels are more retentive than the cemented, but they also produce more stress in the tooth.[67,86,87] The techniques for all of these systems are similar, except for the final dowel space (canal) preparation instrumentation, which is usually specific for the particular dowel system being used.

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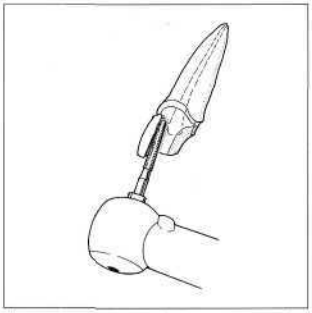


Fig 13-39 The initial step in a dowel-core preparation is reduction for the crown preparation.

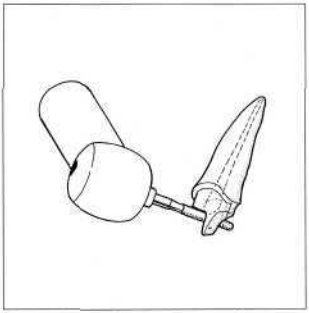


Fig 13-40 Unsupported tooth structure is removed next.

Armamentarium

1. Handpiece
2. Flat-end tapered diamond
3. Small wheel diamond
4. Flame diamond
5. No. 171L bur
6. No. 4 round bur
7. Endodontic condenser
8. Set of six Peeso reamers
9. Dowel kit, including dowel, special reamer, pin(s), and drill
10. Cement spatula and glass slab
11. Amalgam
    a. Copper band and wedges
    b. Capsule(s) and amalgamator
    c. Carrier
    d. Condenser
    e. Carver(s)
12. Composite resin
    a. Crown form (clear or polycarbonate)
    b. Repair kit
    c. Plastic filling instrument

The preparation for a dowel core is begun by preparing the coronal tooth structure for the crown that will be the final restoration for the tooth (Fig 13-39). Remove existing restorations, caries, bases, and thin or unsupported walls of tooth structure (Fig 13-40). Preserve as much coronal tooth structure as possible, to enable the axial walls of the crown to externally brace the tooth.

Measure a Peeso reamer (Union Broach Div of Moyco Industries, Philadelphia, PA) against a radiograph of the tooth being restored to determine the length to which the instrument (and later, the dowel) will be inserted into the canal (Fig 13-41). Slide a silicone rubber endodontic stop onto the shank of the reamer, aligning it with a landmark such as the incisal edge of the adjacent tooth to insure insertion of the instrument to the proper depth in the tooth. Place a rubber dam to prevent contamination of the canal and to protect nearby tissues. Begin the dowel space preparation by first removing gutta-percha in the canal with a hot endodontic condenser.[140] Start enlarging the canal with the largest Peeso reamer or Gates Glidden drill (Union Broach) that will fit into the canal (Fig 13-42).

Even if a specific reamer or drill is prescribed for a particular dowel system, begin with safety-tipped instruments that will follow the path of least resistance, the gutta-percha in the canal (Fig 13-43). With a series of successively larger reamers, enlarge the canal to a diameter slightly smaller than that of the specific instrument required for the system being used. Enlarging a previously instrumented canal in 0.2-mm increments diminishes the possibility of the instrument straying from the canal. Conventional drills used without any prior enlargement of the canal are more prone to stray from the original canal pathway than either Peeso reamers[38] or Gates Glidden drills.[89] Complete the preparation of the dowel space with the prescribed drill or reamer for the system being used (Fig 13-44). General guidelines for the final dowel diameter are shown in Fig 13-45, but individual teeth may require smaller dowels.

In the area of greatest bulk between the canal and the periphery of the tooth, drill one or two 0.6-mm pin holes to a depth of 2.0 mm. Place the pins in these holes to pro-

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Fig **13-41** The depth of insertion of the Peeso reamer is determined by superimposing it over a radiograph of the iooih being restored.

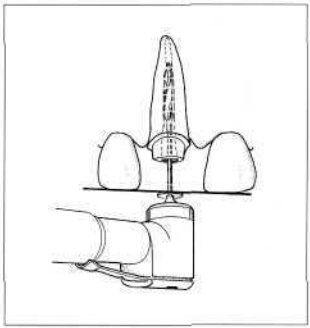


Fig 13-42 The canal is prepared with Keeso rnamers.

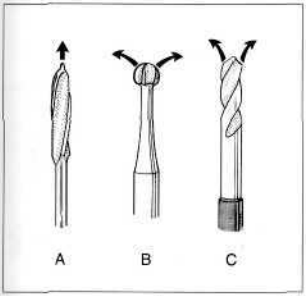


Fig 13-43 A Peeso reamer with a safety tip (A) will follow the path of least resistance, staying within the previously instrumented root canal. A bur (B) or a drill (C) can cut in any direction that it is pushed.

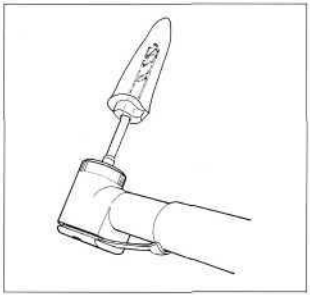


Fig 13-44 The dowel space preparation is finished With the specific drill or reamar for the dowel system being used.

vide antirotational resistance against forces transmitted from the incisal edge of the crown to the core under it. Try in the dowel to confirm fit and length (Fig 13-46). When it is necessary to shorten the dowel, do it at the apical end if the dowel has a special shape to the head, such as the Parapost fColtene/Wh ale dent, Brooklyn, NY). On the other hand, if the dowel has a specially shaped tip, such as the BCH, do any needed shortening at the coronal end.

Make a thin mix of cement, and coat the dowel with it. Introduce cemenl into the dowel space with a plastic instrument. Use a lentulo spiral (LD Caulk, Milford, DE) to insure that the walls of the canal are completely coated

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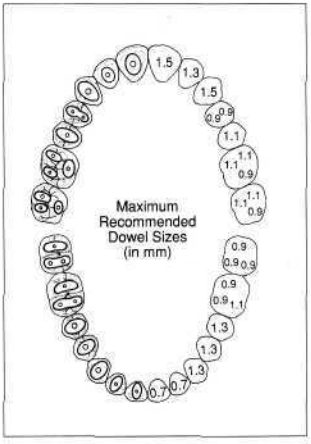


Fig 13-45 The outlines of the roots *(pictured at midroot)* and the dowels are shown superimposed on the occlusal surfaces of the right teeth *(on the reader's left)*. The recommended dowel diameters are shown on the left teeth *(the reader's right)*.

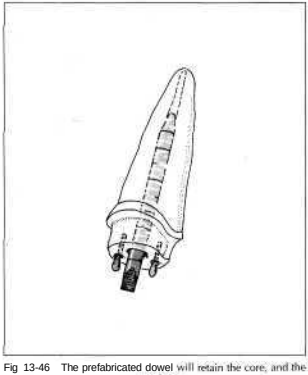


Fig 13-46 The prefabricated dowel will retain the core, and the pin(s) will give it resistance to rotation.

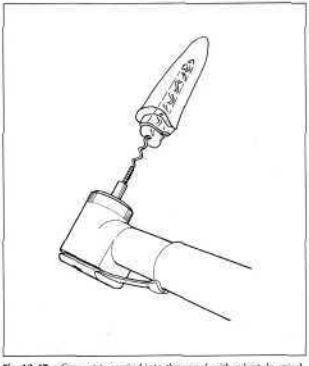


Fig 13-47 Cement is carried into the canal with a lentulo spiral.

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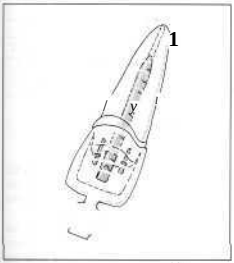


Fig 13-48 The gingival portion of a crown form is cut to follow the contours of the gingiva surrounding the tooth.

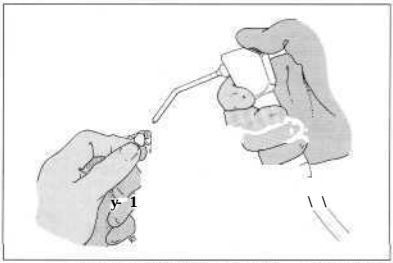


Fig 13-49 Excess separating material (impression material) is blown out of the crown form.

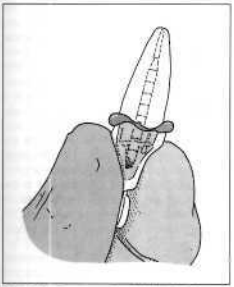


Fig 13-50 The crown form is held while the resin polymerizes.

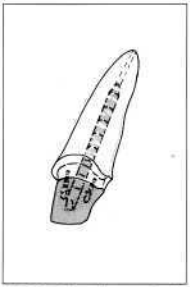


Fig 13-51 The tooth preparation for the final crown is completed.

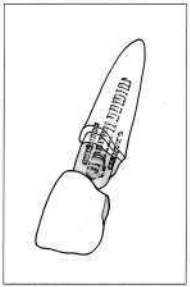


Fig 13-52 The crown is cemented over the the prefabricated dowel and core.

with cement (Fig 13-47). Retention can be increased by as much as 90% if a lentulo spiral is used.[90] Push the dowel slowly to place, allowing the excess cement to escape. Hold the dowel in place with finger pressure until initial set occurs. Then remove excess cement from around the dowel head and pins.

If amalgam will be used for the core, select a copper band of correct diameter to fit the tooth and festoon the gingival end to follow ihe gingival contours. If the core is to be composite resin, a copper band can be used, but it is easier and faster to use a crown form. A clear crown form permits the use of a light-activated resin, while a polycarbonate form can be used with autopolymerizing resins (Fig 13-48).

If a polycarbonate crown form is used, place a separating medium in it. Fill it with light-bodied impression material and blow out the excess with an air syringe, leaving a thin film lining the wails of the crown (Fig 13-49). Then fill the crown form with resin and hold it in position over the protruding dowel until the resin core material has polymerized (Fig 13-50). Remove the matrix and shape the core with diamonds and burs to the form of a crown preparation (Fig 13-51). Be sure that the gingival finish line is on tooth structure.

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Fabricate a provisional restoration and make the impression for the crown. If a polycarbonate crown was used as a matrix, it can be used as the provisional crown after the elastomeric material is peeled out and the margins are refined. The final restoration will be cemented at the return appointment (Fig 13-52).

Table 13-1 *Instrument Sizes*

	Diameter fin mm)						
	0.6	0.7	0.9	1.1	1.3	1.5	1.7
Peeso Reamer	—	1	2	3	4	5	6
Gates Ghdden	1	2	3	4	5	6	—

Custom Cast Dowel Cores

Prefabricated noble-metal dowels have been combined with wax cores.[91,92] Direct wax patterns have been fabricated using either a fissure bur[72] or a paper clip[93] as reinforcement. A direct technique can be used to fabricate a dowel-core pattern from acrylic resin.[94-96]

The direct acrylic dowel-core technique can be used for teeth with single or multiple roots. When a dowel core is made for a premolar with two canals, a dowel of optimal length is made for the most desirable canal, and the second canal accommodates a short key that serves as an antirotational device. It adds little or no retention.

The direct method for fabrication of a dowel core is accomplished in three steps:

1. Canal preparation
2. Resin pattern fabrication
3. Finishing and cementation of the dowel core

Armamentarium

1. Handpiece
2. Flat-end tapered diamond
3. Small wheel diamond
4. Flame diamond
5. No. 170 bur
6. No. 4 round bur
7. Endodontic condenser
8. Set of six Peeso reamers
9. Straight handpiece
10. Coarse garnet disc on a Moore mandrel
11. Fine sandpaper disc on a Moore mandrel
12. Large green stone
13. Burlew wheel on mandrel
14. 14-gauge solid plastic sprue
15. Dappen dish
16. Cement spatula
17. Cotton pellets
18. Petrolatum
19. Resin monomer and polymer
20. Medicine dropper
21. IPPA plastic filling instrument

Canal Preparation

The preparation for the final restoration is roughly approximated. For an anterior tooth, the final restoration will probably be a metal-ceramic crown. Axial reduction and incisal reduction of 2.0 mm are accomplished with a flat-end tapered diamond (Fig 13-53). Labial reduction should be 1.0 to 1.2 mm deep axially. Lingual reduction is done with a small wheel diamond.

All caries, bases, and previous restorations are removed, and the remaining tooth structure is evaluated to determine that which is sound enough to be incorporated into the final preparation. Thin walls of unsupported tooth structure should be removed at this time (Fig 13-54). It is neither necessary nor desirable to remove all supragingival coronal tooth structure unless it is weak and undermined.

The tooth is now ready for preparation of the canal. The instruments of choice for removing the gutta-percha and enlarging the canal are Peeso reamers. They are available in sets of six graduated sizes ranging from 0.7 to 1.7 mm in diameter (Table 13-1). with noncutting tips that follow the path of least resistance, the gutta-percha in the canal.

Begin the removal of gutta-percha in the canal with a hot endodontic condenser. Measure as large a Peeso reamer as will fit in the obturated canal against a radiograph of the tooth being restored to determine the length to which the reamer will be inserted into the canal (Fig 13-55). Use a landmark, such as the incisal edge of an adjacent tooth, to locate a stop on the shank of the reamer. Slide a small square of rubber dam material to the place on the reamer that will correspond with the landmark when the reamer is inserted to the proper depth in the canal

Place the reamer in the tooth to the predetermined depth and expose a radiograph to check the accuracy of the length. Use this radiograph to establish the final length. Continue enlarging the canal with the graduated sizes of reamers until reaching the size that has been decided upon for that tooth. The size of reamer used will depend upon the diameter of the tooth As a general rule, it will be no greater than one-third the diameter of the root at the cementoenamel junction, and there should be a minimum thickness of 1.0 mm of tooth structure around the dowel at midroot and beyond (Fig 13-56).

After the canal has been prepared for the dowel, use a no. 170 bur to make a *keyway,* or groove, in the orifice of the canal. Place it in the area of the tooth where there is the greatest bulk (Fig 13-57). The keyway should be cut to the depth of the diameter of the bur (approximately 0.6 mm) and up the canal to the length of the cutting blades of the bur (approximately 4 mm). On a premolar, the second canal serves the same antirotational function.

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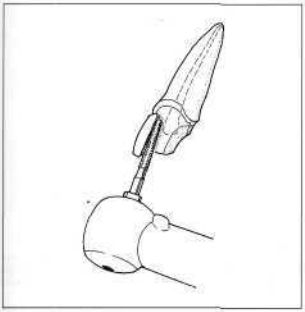


Fig 13-53 The tooth is prepared for a crown as a prelude to the dowel-core preparation.

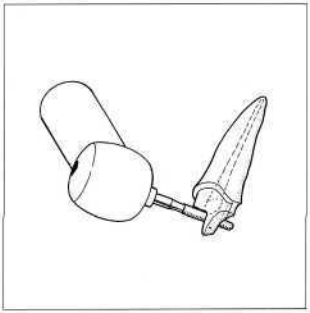


Fig 13-54 Unsupported tooth structure is removed next.

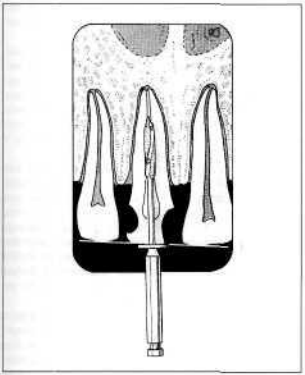


Fig 13-55 A Peeso reamer is superimposed over a radiograph of the tooth being restored to determine the depth of insertion.

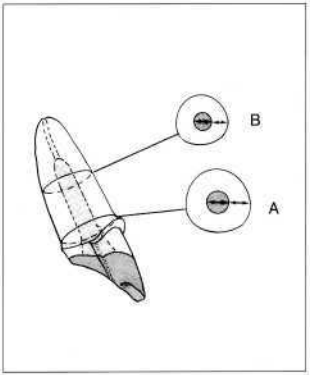


Fig 13-56 Dowel diameter should be no more than one-third the root diameter at the cementoenamel junction (A). It should be at least 2.0 mm less than the crown diameter at midroot (B).

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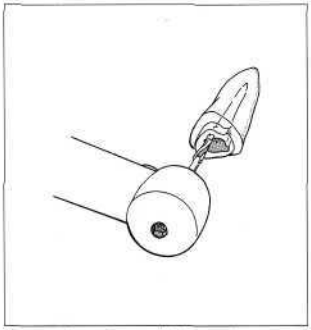


Fig 13-57 A keyway is prepared with a no. 170 bur.

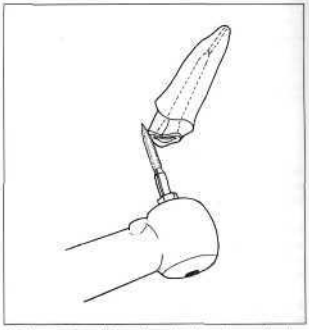


Fig 13-58 A flame diamond is used to place the contrabevel.

If there is supragingival tooth structure, use a flame diamond to place a contrabevel around the external periphery of the preparation (Fig 13-58). This feature provides a metal collar around the occlusal circumference of the preparation to aid in bracing the tooth against fracture of the remaining tooth structure.

Resin Pattern Fabrication

Trim a 14-gauge solid plastic sprue (Williams Dental, Buffalo, NY) so that it will slide easily into the canal to the apical end of the dowel preparation. It must not bind in the canal. Cut a small notch on the facial portion of the occlusal end of the plastic sprue to aid in orienting the dowel-core pattern when it is reseated in subsequent steps (Fig 13-59).

In a dappen dish, mix acrylic resin monomer and polymer to a runny consistency. Lubricate the canal with petrolatum on a small piece of cotton on a Peeso reamer. Fill the orifice of the canal as full as possible with acrylic resin (Duralay, Reliance Dental, Worth, IL) applied with" an IPPA plastic filling instrument. Coat the sprue with monomer and seat it completely in the canal. Make sure that the external bevel is covered at this time (Fig 13-60). Trying to cover the bevel later may disturb the fit of the dowel in the canal.

When the acrylic resin has become tough and doughy, pump the pattern in and out to insure that it will not lock into any undercuts in the canal. As the resin polymerizes, remove the dowel from the canal and make sure that it extends to the apical end of the prepared canal. If there are any voids, they can be filled with a soft, dead wax. such as utility wax. Reinsert the dowel into the canal and move it up and down to insure that it can be withdrawn easily at a later time.

After the resin in the dowel portion has polymerized. relubricate the canal and reseat the dowel. Make a second mix of acrylic resin and place it around the exposed sprus to provide the bulk from which to fashion a preparation for the final restoration (Fig 13-61). While the resin is polymerizing, the coronal portion can be roughly molded on the facial and lingual aspects by holding it between the thumb and forefinger

The core can be roughly shaped in the hand with green stones and coarse garnet discs. The preparation for the final restoration is completed with the dowel-core pattern in place (Fig 13-62). It is desirable to complete reduction and contouring in resin, because it is both difficult and time-consuming to shape the metal after the dowel core has been cast. The finished pattern should be smoothed with fine sandpaper discs and a Burlew wheel (JF Jelenko, Armonk, NY). There should be no roughness or undercuts.

Wipe the dowel-core pattern with an alcohol sponge to remove any residual lubricant that could displace investment or promote bubble formation. Either could result in metal projections that would interfere with complete seating of the cast metal dowel core.

Finishing and Cementation of the Dowel Core

The dowel-core pattern is sprued on the incisal or occlusal end (Fig 13-63). Add 1.0 to 2.0 cc of extra water

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Fig 13-59 A resin sprue is trimmed to fit loosely in the canal.



Fig 13-60 The first mix of resin in the canal should cover the contrabevel.



Fig 13-61 A second mis is added to build up the coronal portion of the dowel core.

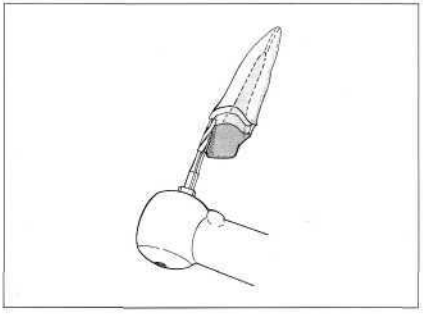


Fig 13-62 Coronal portion of the resin pattern is prepared to relieve the final restoration.

to 50 g of investment, and do not use a liner in the ring. These measures will result in a slightly smaller dowel core that should have less tendency to bind in the canal. The invested pattern should remain in the burnout oven for 30 minutes longer to insure complete elimination oi the resin. After the casting is removed from the investment, it is pickled and the sprue is cut off.

Check the fit of the dowel core in the tooth by seating it with light pressure. If it binds in the canal or will not seat completely, air abrade the dowel and reinsert it in the canal. Relieve any shiny spots. The core portion of the casting should be polished to a satin finish with a Burlew wheel. Cut a groove on the side of the dowel from apical end to contrabevel to provide an escape vent for cement (Fig 13-64).

Mix the cement and insert some of it in the canal with a lentulo spiral. Slowly insert the dowel core into the canal so that the excess cement may escape, allowing the dowel core to seat completely Touch up the preparation for the final restoration, if necessary, and make the impression for it. The crown will be cemented at a subsequent appointment (Fig 13-65).

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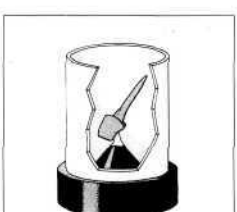


Fig 13-63 Sprued resin pattern in a ring ready for investing.

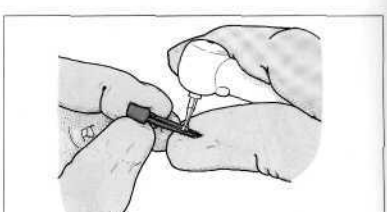


Fig 13-64 A groove is cut in the side of the dowel to allow cement to escape during cementation.

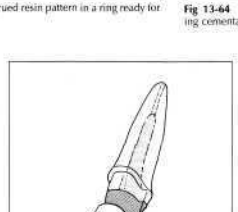


Fig 13-65 Cementation of the final restoration.

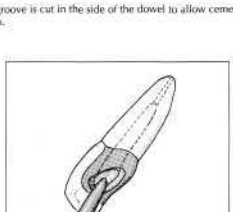


Fig 13-66 A dowel inlay is cemented through the access opening in the crown of an endodontically treated central incisor.

Cast dowel cores can be used on premolars. Mandibular premolars with a single root require no variations in procedure from dowel cores for anterior teeth. On maxillary premolars with two canals, one canal is employed for the dowel preparation, and a stabilizing keyway is placed in the other. Cast dowel-cores are very rarely done on molars, because they have divergent canals that require elaborate, interlocking multipiece castings.

A parallel pin may be added to a prefabricated resin post for antirotational stabilization and some minimal additional retention (Parapost). The canal is prepared with a special drill that is the same diameter as the dowel, and 0.6- or 0.7-mm pin holes are drilled parallel with the canal.[98] A resin core is fabricated over the parallel-sided. serrated, preformed resin post in the canal, with iridioplatinum pins or nylon bristles in the pin holes. The pattern is invested, cast, and cemented in the same manner as a custom pattern.

If endodontic therapy must be done on a tooth after it has received a crown, the access opening will diminish crown retention by approximately 61%.[95] Placement of a *dowel inlay* has been described for stabilizing the crown.*[3] A cast dowel is fabricated on a cast of the prepared tooth, with a slightly flared segment at the coronal end seating into the beveled orifice of the canal (Fig 13-66). If a tooth preparation fractures under a crown, a *retrofit dowel core* can be fabricated under the dislodged crown. The crown is cleaned out, lubricated, and used as a matrix for forming the core portion after the dowel segment of the pattern has been completed in the usual manner.[100]

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