FUNDAMENTALS OF FIXED PROSTHODONTICS

FOURTH EDITION

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Fourth Edition

Cover design based on a photograph of Monument Valley on the Navajo Reservation
in northern Arizona taken at sunrise by Dr Herbert T. Shillingburg, Jr.

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Contents

Dedication

In Memoriam
Constance Murphy Shillingburg
1938–2008

This book is dedicated to the loving memory of Constance Murphy Shillingburg. We met at the University of New Mexico at the beginning of her freshman year in 1956. We were married 4 years later, 1 week after she graduated. During my first 2 years in dental school, I made 13 trips, totaling over 22,000 miles, from Los Angeles to Albuquerque. She shared all of the triumphs and disappointments of my last 2 years in dental school. It was not my career; it was our career. She supported me in all that I did. She didn't question my leaving practice to start a career in academics or our moving from California to Oklahoma. We had three daughters along the way. Although she had three open-heart surgeries in her teens because of rheumatic fever and then two cancer surgeries later in life, she was the most optimistic person I ever met.

She accompanied me on 29 trips outside the United States. At first she came along because she loved to travel, and I didn't enjoy the trips nearly as much without her. However, I very quickly learned that my hosts and audiences were enchanted by her. They enjoyed her as much or more than they did me, and she used what she learned on those trips in her teaching. She died 3 weeks after we celebrated our 48th wedding anniversary. There is a song on the most recent Glen Campbell album, *Ghost on the Canvas*, that sums it up perfectly: "There's no me…without you."

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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 using metal-ceramic artificial teeth (pontics) or metal-ceramic crowns over implants. 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 biologic and mechanical principles, the growth of manipulative skills to implement the treatment plan, and the development of a critical eye and judgement for assessing detail.

As in all fields of the healing arts, there has been tremendous change in this area of dentistry in recent years. Improved materials, instruments, and techniques have made it possible for today's operator with average skills to provide a service whose quality is on a par with that provided 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 serve as 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 subjects. Specific techniques and instruments are discussed because dentists and dental technicians 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 task. However, in the limited time available in the undergraduate dental curriculum, 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 increased use of new cements, new packaging and dispensing equipment 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 usage of periodontally weakened teeth requires different designs for preparations of 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 cosmetic outcome. No longer are metal or ceramics needed to somehow mask the loss of bone and soft tissue. The biggest change in the replacement of missing teeth, of course, is the widespread use of endosseous implants, which make it possible to replace teeth without damaging adjacent sound teeth.

The increased emphasis on cosmetic restorations has necessitated expanding the chapters on those types of restorations. The design of resin-bonded fixed partial dentures has been moved to the chapters on partial coverage restorations. There are some uses for that type of restoration, but the indications are far more limited than they were thought to be a few years ago.

Updated references document the rationale for using materials and techniques and familiarize the reader with the literature in the various aspects of fixed prosthodontics. If more background information on specific topics is desired, several books are recommended: For detailed treatment of dental materials, refer to Kenneth J. Anusavice's *Phillip's Science of Dental Materials, Eleventh Edition* (Saunders, 2003) or William J. O'Brien's *Dental Materials and Their Selection, Fourth Edition* (Quintessence, 2008). For an in-depth study of occlusion, see Jeffrey P. Okeson's *Management of Temporomandibular Disorders and Occlusion, Sixth Edition* (Mosby, 2007). The topic of tooth preparations is discussed in detail in *Fundamentals of Tooth Preparations* (Quintessence, 1987) by Herbert T. Shillingburg et al. For detailed coverage of occlusal morphology used in waxing restorations, consult the *Guide to Occlusal Waxing* (Quintessence, 1984) by Herbert T. Shillingburg et al. Books of particular interest in the area of ceramics include W. Patrick Naylor's *Introduction to Metal Ceramic Technology* (Quintessence, 2009) and Christoph Hämmerle et al's *Dental Ceramics: Essential Aspects for Clinical Practice* (Quintessence, 2009).

—Herbert T. Shillingburg, Jr, DDS

Acknowledgments

No book is the work of just its authors. It is difficult to say which ideas are our own and which are an amalgam of those with whom we have associated. Two fine restorative dentists had an important influence on this book: Dr Robert Dewhirst and Dr Donald Fisher have been mentors, colleagues, and, most importantly, friends. Their philosophies have been our guide for the last 40 years. Dr Manville G. Duncanson, Jr, Professor Emeritus of Dental Materials, and Dr Dean Johnson, Professor Emeritus of Removable Prosthodontics, both of the University of Oklahoma, were forthcoming through the years with their suggestions, criticism, and shared knowledge. Thanks are also due to Mr James Robinson of Whip-Mix Corporation for his help with materials and instruments in the chapters that deal with laboratory procedures. Appreciation is expressed to Dr Mike Fling for his input regarding tooth preparations for laminate veneers. Thank you to Mr Lee Holmstead, Brasseler USA, for his assistance with the illustrations of the diamonds and carbide burs.

Illustrations have been done by several people through the years: Mr Robert Shackelford, Ms Laurel Kallenberger, Ms Jane Cripps, and Ms Judy Amico of the Graphics and Media Department of the University of Oklahoma Health Sciences Center. Artwork was also contributed by Drs Richard Jacobi and Herbert T. Shillingburg. This book would not have come to fruition without the illustrations provided by Ms Suzan Stone and the computer program, *Topaz Simplify*, suggested by Mr Alvin Flier, a friend from 40 years ago in Simi, California. A special thank you to the Rev John W. Price of Houston, Texas, for restoring my sense of mission in June 2008.

Thanks to you all.

An Introduction to Fixed Prosthodontics

1

The scope of fixed prosthodontics 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 esthetics can be achieved. Missing teeth can be replaced with fixed prostheses that will 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, through the use of fixed restorations, to render an optimal occlusion that improves the orthopedic stability of the temporomandibular joints (TMJs). 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 or permanently affixed 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 the entire clinical crown, the restoration is called a *full veneer*, *full coverage*, *complete*, or just a *full crown* (Fig 1-1). It may be fabricated entirely of a gold alloy or another 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 coverage* or *partial veneer crown* (Fig 1-2).

Intracoronal restorations are those that fit within the anatomical contours of the clinical crown of a tooth. *Inlays* may be used as single-tooth restorations for Class II proximo-occlusal or Class V gingival lesions with minimal to moderate extensions. They may be made of gold alloy (Fig 1-3a), a ceramic material (Fig 1-3b), or processed resin. When modified with occlusal coverage, the intracoronal restoration is called an *onlay* and is useful for restoring more extensively damaged posterior teeth needing wide *mesio-occlusodistal (MOD) restorations* (Fig 1-4).

Another type of cemented restoration that has gained considerable popularity in recent years is the all-ceramic *laminate veneer*, or *facial veneer* (Fig 1-5). It is used on anterior teeth that require improved esthetics but are 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 that is permanently attached to remaining teeth or implants and replaces one or more missing teeth (Fig 1-6). In years past, this type of prosthesis was known as a *bridge*, a term that has fallen from favor[1,2] and is no longer used.

A tooth or implant serving as an attachment for a fixed partial denture is called an *abutment*. The artificial tooth suspended from the abutments is a *pontic*. The pontic is connected to the fixed partial denture retainers, which are extracoronal restorations that are cemented to or otherwise attached to the abutment teeth or implants. Intracoronal restorations lack the necessary retention and resistance to be used as fixed partial denture retainers. The *connectors* between the pontic and the retainer may be rigid (ie, solder joints or cast connectors) or nonrigid (ie, precision attachments or stress breakers) if the abutments are teeth. As a rule, only rigid connectors are used with implant abutments.

Diagnosis

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

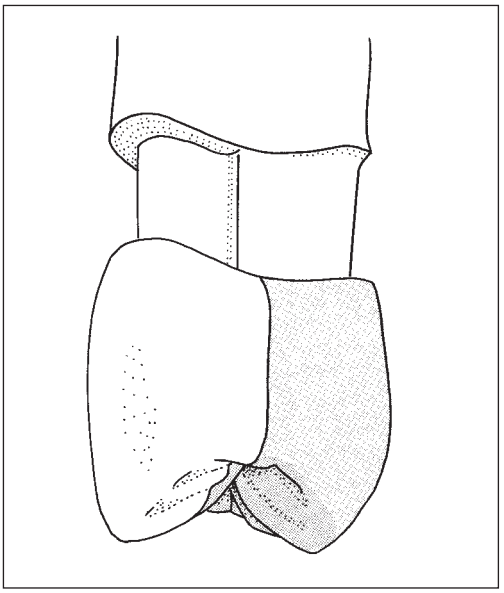

Fig 1-1 A full veneer, full coverage, or complete crown covers the entire clinical crown of a tooth. The example shown is a metal-ceramic crown.

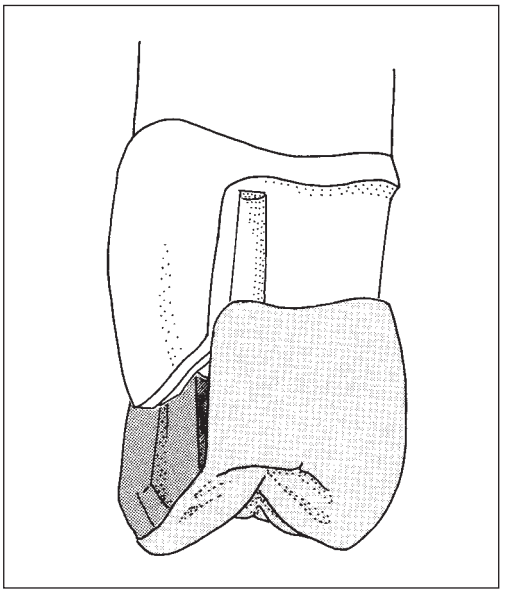

Fig 1-2 A partial veneer or partial coverage crown covers only portions of the clinical crown. The facial surface is usually left unveneered.

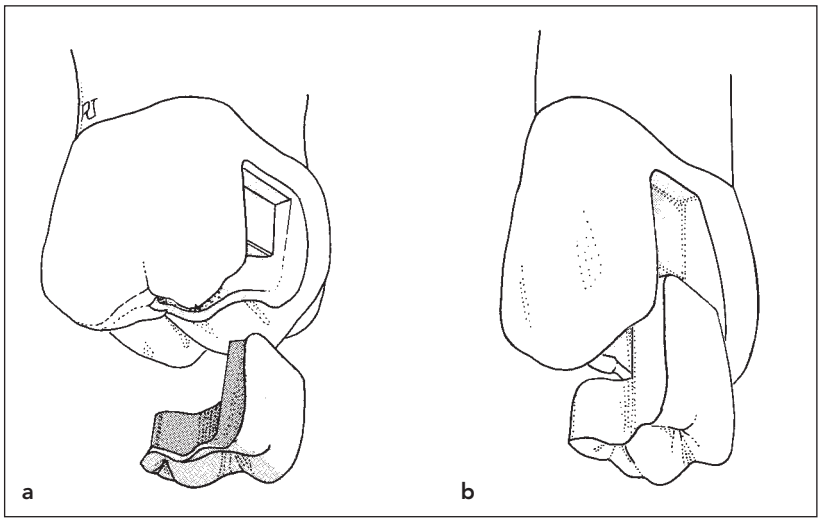

Fig 1-3 Inlays are intracoronal restorations with minimal to moderate extensions made of gold alloy *(a)* or a ceramic material *(b)*.

There are five elements to a good diagnostic work-up in preparation for fixed prosthodontic treatment:

1. Health history
2. TMJ and occlusal evaluation
3. Intraoral examination
4. Diagnostic casts
5. Full-mouth radiographs

Health 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 treatments might be canceled or postponed because of the patient's physical or emotional health. It may be necessary to premedicate patients with certain conditions or to avoid medication for others.

It is not within the scope of this book to describe all the conditions that might influence patient treatment. However, there are some whose frequency or threat to the patient's

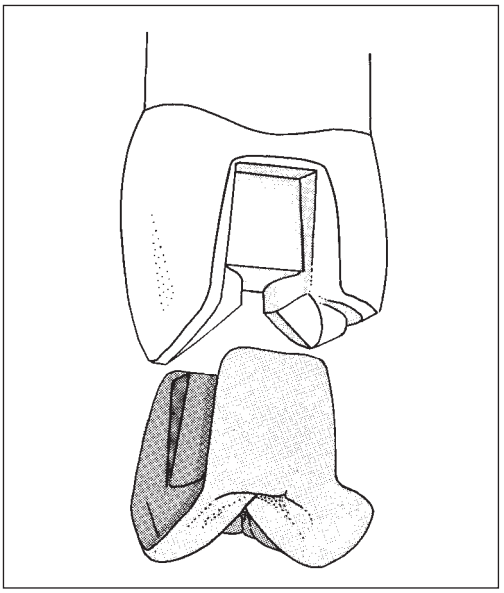

Fig 1-4 An onlay is an intracoronal restoration with an occlusal veneer.

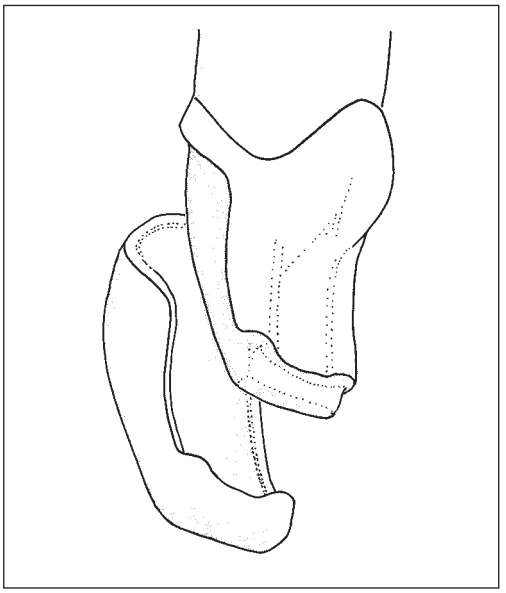

Fig 1-5 A laminate veneer is a thin layer of porcelain or cast ceramic that is bonded to the facial surface of a tooth with resin.

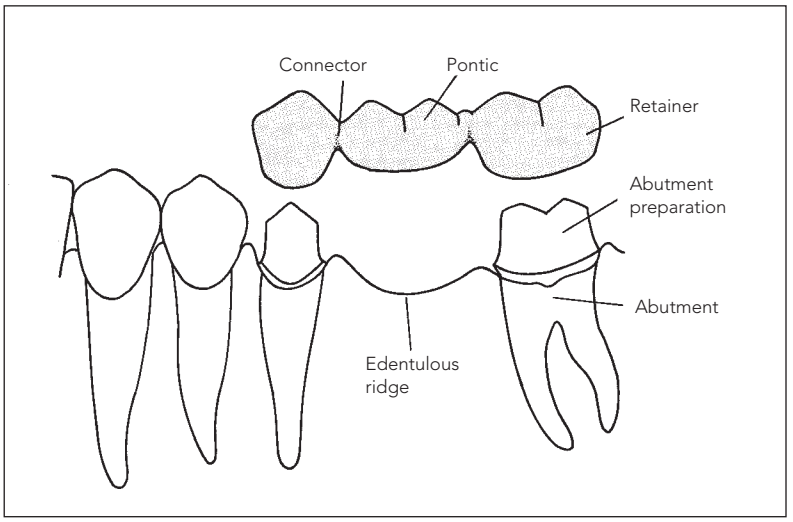

Fig 1-6 The components of a fixed partial denture.

or office staff's well-being is significant enough to merit discussion. A history of infectious diseases, such as serum hepatitis, tuberculosis, and human immunodeficiency virus (HIV)/AIDS, 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.

Medications

The patient should be asked what medications, prescribed or over-the-counter, are currently being taken and for what purpose.[3] It is important to be aware that an estimated 25% of the population is taking some type of herbal product.[4] All medications should be identified and their contraindications noted before proceeding with treatment. The patient should be questioned about current medications at each subsequent appointment to ensure that information on the patient's medication regimen is kept up to date.

Allergies

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 in the patient's record so that the medication is not administered or prescribed. Local anesthetics and antibiotics are the most common allergenic drugs.

The patient might also report a reaction to a dental material. Impression materials and nickel-containing alloys are leading candidates in this area. It is imperative that the dentist not engage in any type of improvised allergy testing to corroborate the patient's recollection of previous problems. It is possible to initiate a life-threatening anaphylactic reaction by challenging the patient's immune system with an allergen to which he or she has been previously sensitized.

Cardiovascular disorders

Patients who present with a history of cardiovascular problems require special attention. Hypertension affects nearly 50 million Americans.[5] Thirty percent of those with high blood pressure (HBP) are not aware of having the condition; only 59% of them are being treated for it; and only 34% have their blood pressure controlled to recommended levels.[6] Based on these statistics, it is probable that dentists see numerous patients with undetected or uncontrolled HBP, who are prime candidates for disastrous cardiovascular events. Therefore, dentists should check blood pressure of all patients at the first appointment and at subsequent visits. No patient with uncontrolled hypertension should be treated until the blood pressure has been lowered.

The 7th Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7) has revised guidelines that simplify blood pressure classification.[6] There are two categories of hypertension:

- Stage 1: systolic blood pressure (SBP) ≥ 140–159 mm Hg or diastolic blood pressure (DBP) ≥ 90–99 mm Hg
- Stage 2: SBP ≥ 160 or DBP ≥ 100

In this simplified classification, *prehypertension* describes SBP = 120–139 mm Hg or DBP = 80–89 mm Hg. This replaces the category called *high normal* (SBP = 130–139, DBP = 85–89 mm Hg).[6] Risk of a stroke or heart attack doubles for each 20/10 mm Hg incremental blood pressure increase above 115/75 mm Hg.[7] For most patients, treatment should be performed only if blood pressure is below 140/90 mm Hg,[6,8] but in patients with diabetes or kidney disease, blood pressure should be lower than 130/80 mm Hg.[9,10]

Epinephrine in local anesthetic is contraindicated for patients with severe cardiovascular disease but not for patients with mild-to-moderate forms of the disease if the number of carpules used is limited to two or three.[6] The rationale is that lessening of pain will decrease the endogenous release of epinephrine, which could be 20 to 40 times greater if the patient becomes stressed by pain.[11] Retraction cord, however, does not provide any such potential benefit; therefore, cord containing epinephrine is contraindicated. Because of the availability of numerous alternatives for hemostasis and sulcus enlargement, the use of epinephrine-impregnated cords is not warranted.[6]

Patients on oral anticoagulant therapy are the most likely to experience hemorrhagic problems during dental treatment.[12] They may be taking anticoagulants for a variety of reasons: prosthetic heart valves, myocardial infarction (MI), stroke (cerebrovascular accident [CVA]), atrial fibrillation (AF), deep venous thrombosis (DVT), or unstable angina.[13] The two most widely used coumarin derivatives are warfarin sodium (Coumadin [Bristol-Myers Squibb]) and bishydroxycoumarin (dicumarol), both of which are vitamin K antagonists.[12]

Anticoagulation level is measured by the international normalized ratio (INR). A patient whose blood coagulates normally would have an INR of 1.0.[13] Increasing the anticoagulant effect increases the INR.[12] The INR range recommended by the American College of Chest Physicians[14] and endorsed by the American Heart Association (AHA)[15] is 2.0 to 3.0 in every situation mentioned previously, except for prosthetic heart valves, for which the INR range should be 2.5 to 3.5. The INR for artificial heart valves should not exceed 4.0.[16]

The patient's physician should be consulted to learn why the patient is on anticoagulants,[12] the most recent INR value,[13,17] and when it was taken. Anticoagulant therapy is the responsibility of the physician, not the dentist. However, the physician may recommend stopping anticoagulant therapy 2 to 3 days prior to treatment, which is the traditional management of patients on anticoagulants, although the dental literature indicates that this may not be the optimal approach.[18]

An update of the recommendations by the AHA for prevention of infective endocarditis (IE) was issued in 2007.[19] Guidelines were first published in 1955, and the most recent update before the present one was published in 1997. The current guideline greatly reduces the number of patients who should be premedicated, stating, "Only an extremely small number of cases of infective endocarditis (IE) might be prevented by antibiotic prophylaxis even if it were 100% effective."[19]

Antibiotic prophylaxis for dental procedures now is recommended only for patients with cardiac conditions with the greatest risk of adverse outcome from IE[19]:

- Prosthetic heart valve
- Previous IE
- Congenital heart disease (CHD)
- Unrepaired cyanotic CHD
- CHD repaired with a prosthetic material for 6 months after repair
- Repaired CHD with residual defect at or near the prosthetic patch that would interfere with endothelialization
- Cardiac transplants that develop valvulopathy

For patients with these conditions, prophylaxis is recommended for all dental procedures that involve the gingiva, the periapical region of the teeth, or perforation of oral mucosa.

The antibiotic regimen now recommended is a single 2-g oral dose of amoxicillin for adults who are not allergic to penicillin, 30 to 60 minutes before the procedure.[19] There is no need to prescribe a follow-up dose after the procedure. If the patient is allergic to penicillin, 600 mg clindamycin or 500 mg azithromycin or clarithromycin may be substituted. If none of these is acceptable, consult the patient's physician or the guidelines article in the June 2007 issue of the *Journal of the American Dental Association*.[19]

Patients with valvular dysfunction from rheumatic heart disease (RHD),[20] mitral valve prolapse (MVP) with valvular regurgitation,[21] systemic lupus erythematosus,[22] and valvulopathy resulting from the diet medication fenfluramine-phentermine ("fen-phen")[23] were once indicated for antibiotic prophylaxis, but following the 2007 guidelines set by the AHA, they no longer require premedication.[19] Most unrepaired congenital heart malformations still do require antibiotic prophylaxis.[19] Patients with cardiac pacemakers do not require prophylaxis.[19]

With regard to artificial joints, the American Dental Association (ADA) states, "Antibiotic prophylaxis is not indicated for dental patients with pins, plates or screws, nor is it routinely indicated for most dental patients with total joint replacements. However, it is advisable to consider premedication in a small number of patients who may be at risk of experiencing hematogenous total joint infection."[24] For those patients not allergic to penicillin who do require premedication, 2 g amoxicillin taken orally 1 hour prior to the dental procedure is the antibiotic of choice. For variations of this regimen, the reader is referred to the advisory statement in the July 2003 issue of the *Journal of the American Dental Association*.[24]

Patients who are on an antibiotic regimen prescribed to prevent the recurrence of rheumatic fever are not adequately premedicated to prevent IE.[19] It is very possible that these patients will have developed strains of microorganisms that have some resistance to amoxicillin. If they require prophylactic antibiotic coverage, it would be wise to prescribe a different type than the one they are taking. Tetracyclines and sulfonamides are not recommended.

Epilepsy

Epilepsy is another patient condition of which the dentist should be aware. 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. 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.

Diabetes

More than 18 million Americans have diabetes, and another 41 million are "prediabetic."[25] Diabetic patients are predisposed to periodontal breakdown or abscess formation.[26,27] Well-controlled diabetic patients should be able to report their self-monitoring blood glucose (SMBG) from that morning. This value, which they obtain by placing a drop of their blood in a glucometer, is a measure of their capillary plasma glucose. Their *preprandial* (fasting) reading should be in the 90 to 130 mg/dL range. Their peak *postprandial* (after meals) reading should be 180 mg/dL.[28] A long-term measure of diabetic patients' glycemic control is their *glycosylated hemoglobin* (HbA_{1c}), a lab test that measures how much glucose is tied to red blood cells (Table 1-1). Its correlation with daily blood glucose numbers is 0.84.[29] It can be considered the average blood glucose level over the previous few months.[30]

Table 1-1 Correlation between HbA_{1c} and mean plasma glucose[29]

HbA_{1c}	6	7	8
Mean plasma glucose (mg/dL)	126	154	183

Those whose diabetes is poorly controlled will have elevated blood sugar, or *hyperglycemia*, and could be adversely affected by the stress of a dental appointment. *Hypoglycemia* (low blood sugar) can also cause problems. A controlled diabetic (on medication) who has missed a meal or has not eaten for several hours may become sweaty, lightheaded, and disoriented. These patients usually carry some quick source of glucose, such as candy, which should be administered. Four ounces of a regular soft drink or fruit juice or several pieces of hard candy should help them recover quickly. Treatment should be halted for that appointment, and the patient should be monitored at the office until complete recovery can be confirmed. It would be wise to have a family member drive the patient home. Dental treatment for the diabetic patient 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 the patient's physician before proceeding.

Xerostomia

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. Xerostomia can be caused by large doses of radiation in the oral region,[31] lupus erythematosus,[22,32] or Sjögren syndrome, an autoimmune disease.[33] Sjögren syndrome frequently is first noticed and diagnosed by a dentist because of the xerostomia.[34] It is frequently seen in conjunction with other autoimmune diseases, such as rheumatoid arthritis, lupus erythematosus, and scleroderma.[33]

There are approximately 400 drugs capable of producing mild to severe xerostomia.[3,35] 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 dry mouth.

Osteonecrosis

A relatively new problem that has arisen in relation to drug side effects and dental treatment is bisphosphonate-related osteonecrosis of the jaws (BRONJ). There is some controversy regarding the etiology and pervasiveness of this condition. Over the past 7 years, more than 4,000 cases have been reported to the Food and Drug Administration.[36] This family of drugs is administered intravenously (IV) to treat metastatic bone cancer, and the greatest risk of osteonecrosis occurs in these patients. Bisphosphonates are used more widely, but at lower dosage levels, as an oral preventive treatment for osteoporosis. The ratio of patients on oral bisphosphonate therapy who have developed osteonecrosis compared with those on the IV drug has varied from 10%[37] to as high as 83%.[38]

Osteonecrosis was initially associated with oral surgery, but there have been reports of spontaneous occurrences without surgery at rates as high as 25%.[39,40] Scully et al[41] have stated that bisphosphonate therapy is a contraindication for dental endosseous implants, and at the present time, Marx et al[39] strongly discourage implant placement in patients taking bisphosphonates.

Current complaint and patient expectations

As part of the health history, 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 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. Moreover, an effort should be made to get an accurate description of the patient's expectations for the treatment results. Particular attention should be paid to the esthetic 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 and occlusal evaluation

Prior to the start of fixed prosthodontics procedures, the patient's occlusion and TMJs must be evaluated to determine if they are healthy enough to allow the fabrication of restorations. If the occlusion and TMJs are within normal limits, then treatment should be designed to maintain that relationship. However, if the occlusion or one or both TMJs are dysfunctional in some manner, further appraisal is necessary to determine whether the dysfunction can be improved prior to the placement of the restorations or if restorations should not be placed.

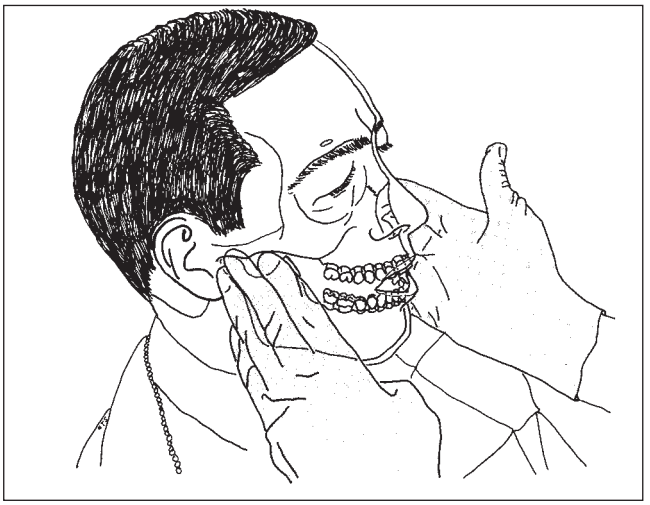

Fig 1-7 The joints are palpated as the patient opens and closes to detect signs of dysfunction.

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. It may be *referred pain*, ie, it may not originate from the area where the pain is experienced.[42] Many patients suffer from undiagnosed muscle and/or joint dysfunction of the head and neck region; such a history should be investigated further.

Next, an assessment of the TMJs themselves should be performed. Healthy TMJs function with no evidence of pain. Asymptomatic clicking or crepitation occurs in about one-third of the general population.[43] Limitation of movement on opening, closing, or moving laterally should be investigated further to determine the condition of the TMJs. 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. Habits such as clenching the teeth and manipulating the bite during the course of the daily routine may result in fatigue and muscle pain. The physical appearance and activities of the patient should be observed for signs of such habits. Many times they will have a square-jowled appearance, with masseter muscles that are overdeveloped from hyperactivity. They may even clench their teeth during the patient interview.

A brief palpation of the masseter (Fig 1-8), temporalis (Fig 1-9), medial pterygoid (Fig 1-10), trapezius (Fig 1-11), and sternocleidomastoid (Fig 1-12) muscles may reveal tenderness. The patient may demonstrate limited opening due to tightness of the masseter, temporalis, and/or medial pterygoid muscles. This can be noted by asking the patient to

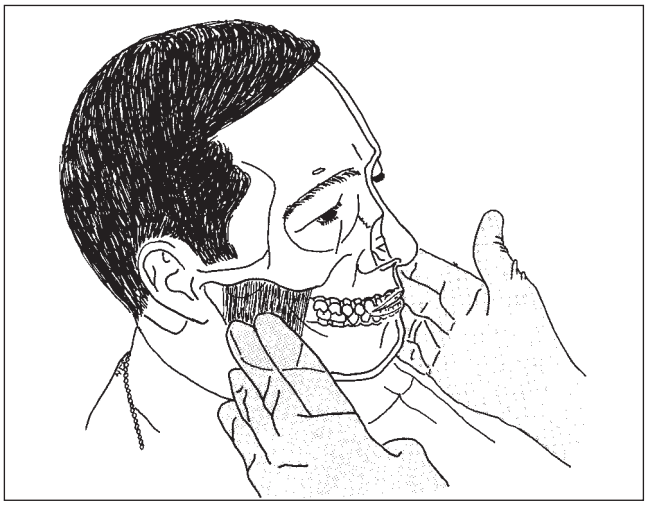

Fig 1-8 The masseter muscles are palpated extraorally by placing the fingers over the lateral surfaces of the rami of the mandible.

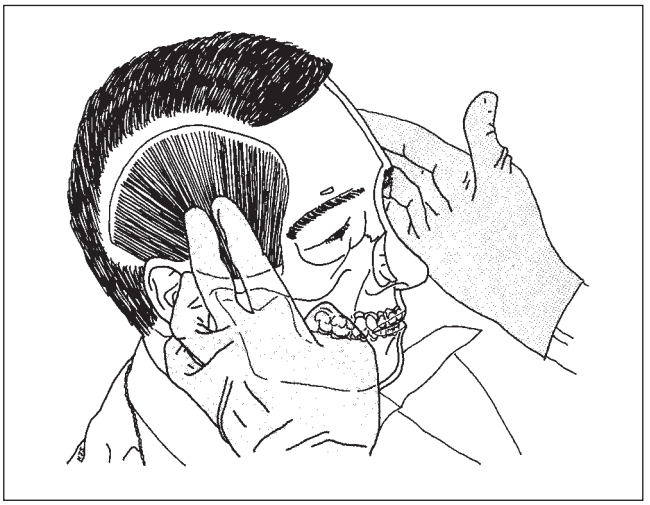

Fig 1-9 The fingers are placed over the patient's temples to feel the temporalis muscles.

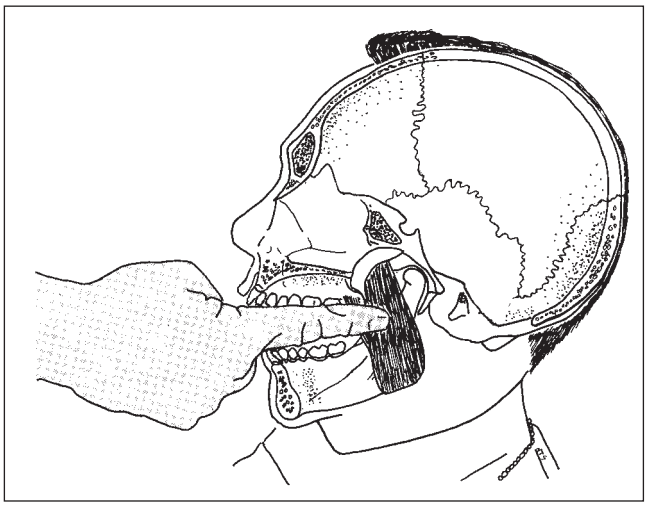

Fig 1-10 The index finger is used to touch the medial pterygoid muscle on the inner surface of the ramus.

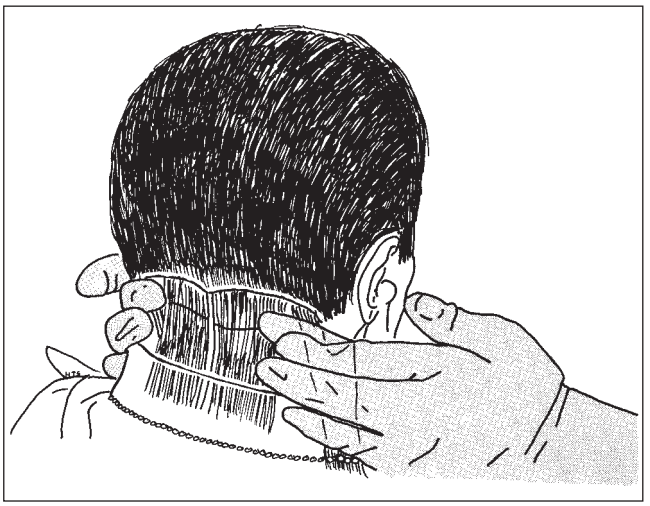

Fig 1-11 The trapezius muscle is felt at the base of the skull, high on the neck.

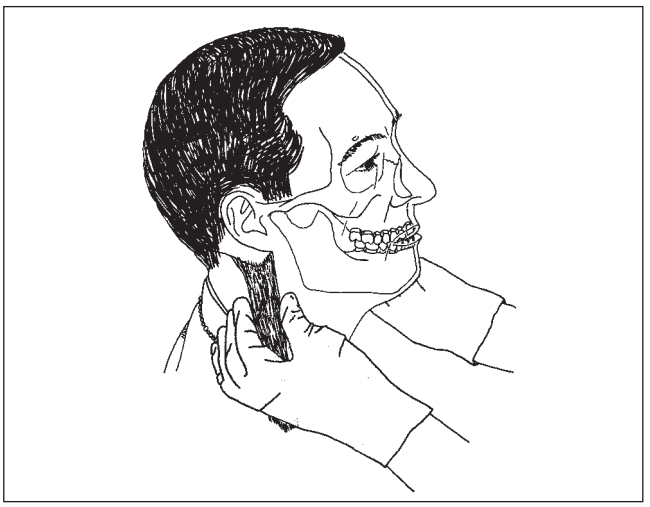

Fig 1-12 The sternocleidomastoid muscle is grasped between the thumb and forefingers on the side of the neck. The muscle can be accentuated by a slight turn of the patient's head.

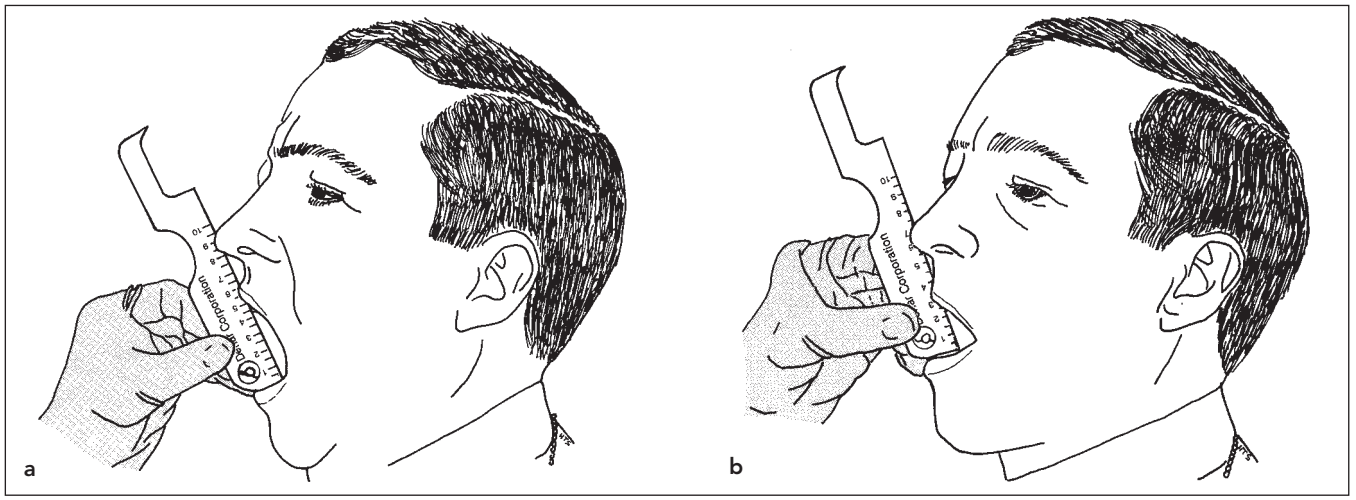

Fig 1-13 *(a)* The distance between the maxillary and mandibular incisors is measured when the patient is instructed to open "all the way." *(b)* If the patient can only open partially, or opens very slowly, the cause should be determined.

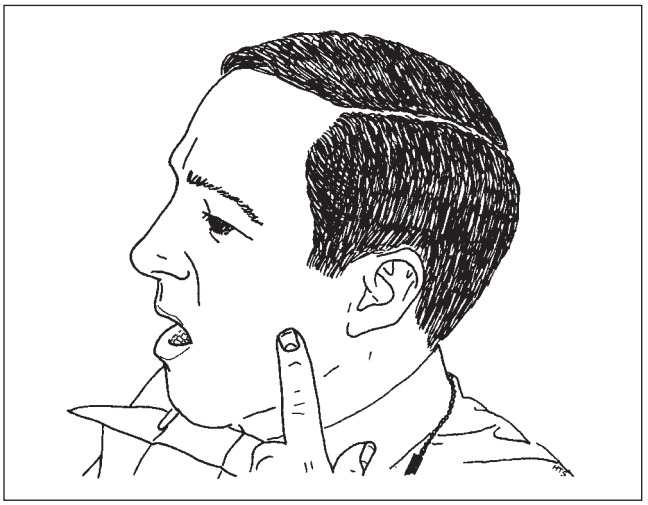

Fig 1-14 If opening is limited or painful, the patient should be instructed to use a finger to indicate the area that hurts.

open "all the way" (Fig 1-13). If it appears that the opening is limited or the movement is slowed, ask the patient to point to the area that hurts (Fig 1-14). If the patient touches a muscle area, as opposed to the TMJ, there is probably some dysfunction of the neuromuscular system. Patients experiencing a problem with one or both TMJs will most frequency point to the joint itself.

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

Intraoral examination

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

Edentulous ridges should be examined, and the relationship of spaces should be noted if there is more than one. What is the condition of prospective abutment teeth? The presence and location of caries should be noted. 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 provide insight into the prognosis for the 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 if they are suitable or if they need to be replaced. It will help to determine the prognosis for future work to be done.

Finally, an evaluation should be made of the occlusion itself. Are there large facets of wear? Are they localized or widespread? Are there any nonworking interferences? The amount of slide between the centric relation position and the maximal intercuspal position should be noted. Is the slide a straight one, or does the mandible deviate to one

side? 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 what 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 regarding the patient's dental needs. To accomplish their intended goal, the casts must be accurate reproductions of the maxillary and mandibular arches, made from distortion-free alginate impressions. The casts should contain neither bubbles as a result of faulty pouring nor any positive nodules on the occlusal surfaces ensuing from air entrapment during the taking of the impression.

To derive maximum benefit from the diagnostic casts, they should be mounted on a semi-adjustable articulator. When they have been positioned with a facebow and the articulator adjustments have been set using lateral interocclusal records, a reasonably accurate simulation of jaw movements is possible. The articulator settings should be included in the patient's permanent record to facilitate resetting the instrument when restorations are fabricated for this patient at a 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, which enables prediction of 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 also becomes evident; as a result, 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. The difference between the centric relation position and the intercuspal position should be noted. 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 relation prematurities or excursive interferences can be determined. The relationship of the anterior teeth and the anterior guidance can be viewed and analyzed. 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 that are wider or narrower than the teeth that would normally occupy the edentulous space require 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 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 periapical 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 pathologies 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 the 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 hepatitis B virus (HBV), hepatitis C virus (HCV), or HIV. Although AIDS has received greater publicity and generated near hysteria in the recent past, hepatitis is the major

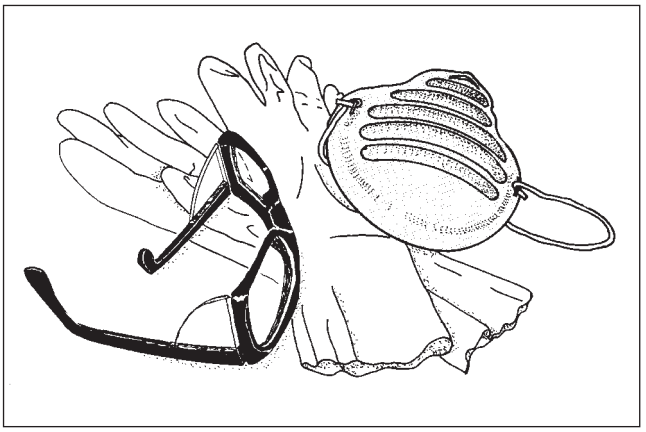

Fig 1-15 Rubber gloves, a surgical mask, and eye protection are important for safeguarding dental office personnel.

infectious occupational hazard to health care professionals.[44] HCV is the most common chronic, blood-borne infection in the United States[45] and is transmitted primarily through contact with blood from an infected individual.[45] It has been estimated that 3.2 million Americans have been infected with HCV.[46]

There is no evidence that these diseases are contracted through 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 HBV is available and is recommended by the Centers for Disease Control[47–49] and the ADA Council on Dental Therapeutics[50] for all dental personnel who have contact with patients. There is no vaccine against HCV.

While special precautions should be taken 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 1-15).

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 specifics of decontaminating impressions are covered in chapter 17.

In addition, steps must be taken in a receiving area of the laboratory to isolate and decontaminate items coming from the dental operatory.[50] 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.[51] There is more to dental laboratory work than manipulating inert gypsum, wax, resins, metal, and ceramics.

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Fundamentals of Occlusion

2

Unfortunately, the occlusion is frequently overlooked or taken for granted in providing restorative dental treatment to patients. This may be due in part to the fact that the symptoms of occlusal disorders are often hidden from the practitioner untrained to recognize them or to appreciate their significance. Long-term successful restoration with cast metal or ceramic restorations is dependent on the maintenance of occlusal harmony.

While it is not possible to present the philosophies and techniques required to render extensive occlusal reconstruction in this limited space, it is essential that the reader develop an appreciation for the importance of occlusion. The perfection of skills required to provide sophisticated treatment of complex occlusal problems may take years to acquire. However, the minimum expectation of the competent practitioner is the ability to diagnose and treat simple occlusal disharmonies and to produce restorations that will not create iatrogenic occlusal or temporomandibular disorders.

Centric Relation

In restorative treatment, the goal is to create occlusal contacts in posterior teeth that stabilize the mandibular position instead of creating deflective contacts that may destabilize it. In restorative treatment, the occlusion should be in harmony with the optimum condylar position, *centric relation*, which is an anteriorly, superiorly braced position along the articular eminence of the glenoid fossa, with the articular disc interposed between the condyle and eminence.[1] This position is the most orthopedically stable position, and because it is a result of activated elevator muscles, it is also the most musculoskeletally stable position.[2]

This position of the condyles in the glenoid fossae has been discussed and debated for years. It is used in dentistry as a repeatable reference position for mounting casts in an articulator.[3,4] The term attempts to define the optimum relative position between all of the anatomical components. Ideally, that condylar position is also coincident with maximal intercuspation of the teeth.[4,5]

For the concept of centric relation to be meaningful, the basic anatomy of the temporomandibular joint (TMJ) must be understood (Fig 2-1). The bone of the glenoid fossa is thin at its most superior aspect and is not suited to be a stress-bearing area. However, the slope of the eminence in the anterior aspect of the fossa is composed of thick cortical bone that is capable of bearing stress.

The articular disc is biconcave, devoid of nerves and blood vessels in the central area, and tough—much like a piece of shoe leather. It has a few muscle fibers attached in the anterior aspect from the superior lateral pterygoid muscle. The disc is attached to the condyle on its medial and lateral aspects and should be interposed between the condyle and articular eminence during function. The condyle is not spherical but has an irregular, elliptical shape. This shape helps to distribute stress throughout the TMJ rather than concentrating it in a small area.

Many methods have been used to guide the mandible into an optimal position. Earlier concepts of centric relation involved the most posterior condylar position in the fossa. The condyle was sometimes forcefully manipulated into the rearmost, uppermost, and midmost (RUM) position within the glenoid fossa,[4,6–8] using chin point guidance. However, when the condyle is retruded, it might not be seated on the central area of the articular disc; instead, it might be on the highly vascular and innervated retrodiscal tissues (the posterior attachment) posterior to the disc[9] (Fig 2-2). This can occur if the inner horizontal portion of the temporomandibular ligament has been unduly traumatized so that it no longer supports the condyle in a more anterior, physiologic position. It is presently thought that rather than being a physiologic position, this is frequently an abnormal, forced position that could create unnecessary strain in the TMJ. In this circumstance, the disc is displaced anteriorly, and clicking of the joint is frequently observed as the patient opens and closes.

The more recent concept describes a physiologic position in terms of the musculoskeletal relationships of the structures[10] (Fig 2-3). It is not a forced position; rather, the mandible is gently guided by the operator using the bilateral method[11] or by allowing natural muscle action to place the condyle in a physiologically unstrained position.[12]

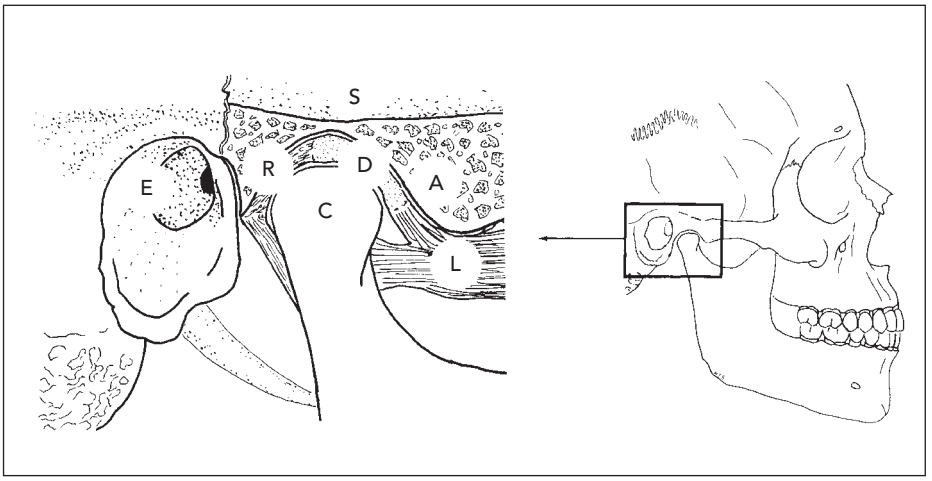

Fig 2-1 Some of the components of the TMJ. A, articular eminence; C, condyle; D, articular disc; E, external auditory meatus; L, superior and inferior lateral pterygoid muscles; R, retrodiscal tissue (posterior attachment); S, thin superior wall of the glenoid fossa.

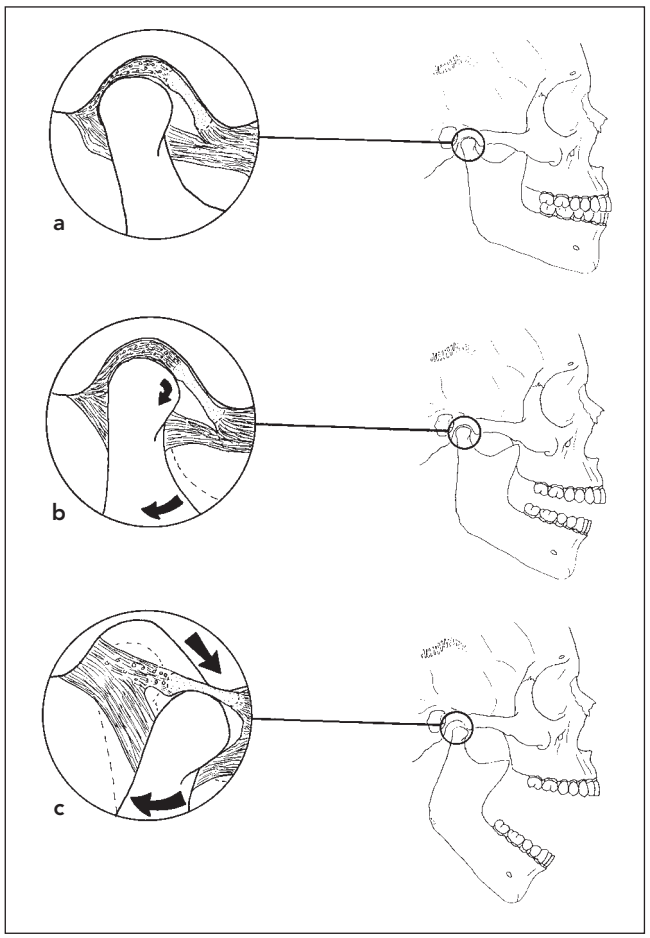

Fig 2-2 *(a)* In a dysfunctional joint with an internal derangement, the disc is displaced anterior to the condyle at the intercuspal position. *(b)* After initial rotational opening, the condyle is still posterior to the disc. *(c)* In translation of the mandible to maximum opening, the condyle recaptures the disc, clicking into position as it does.

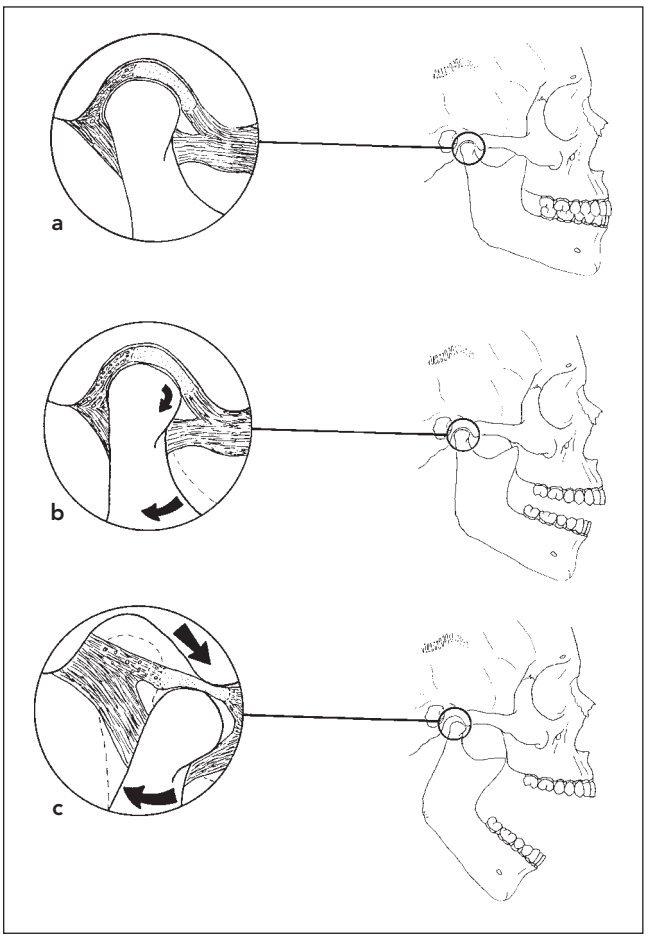

Fig 2-3 *(a)* In a healthy joint, the condyle is in a superoanterior position in the fossa with the articular disc interposed when the teeth are in maximal intercuspation. *(b)* In the initial stage of opening, the condyle rotates in position, with the disc remaining stationary. *(c)* In maximum opening, the condyle translates forward, with the disc still interposed.

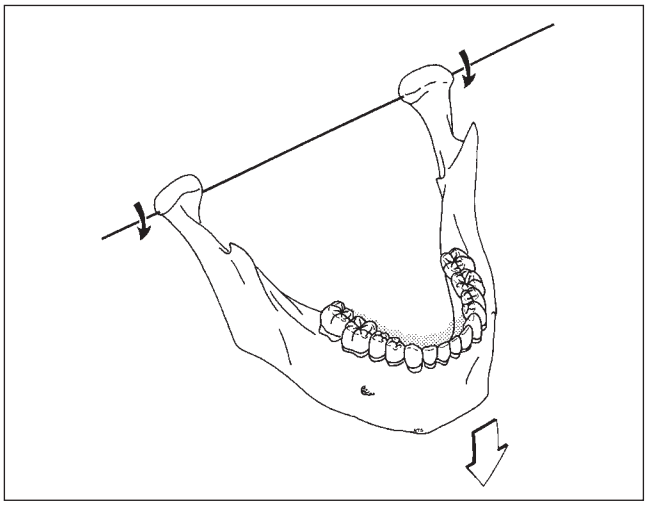

Fig 2-4 The mandible moves on a horizontal axis, as seen in a hinge axis opening.

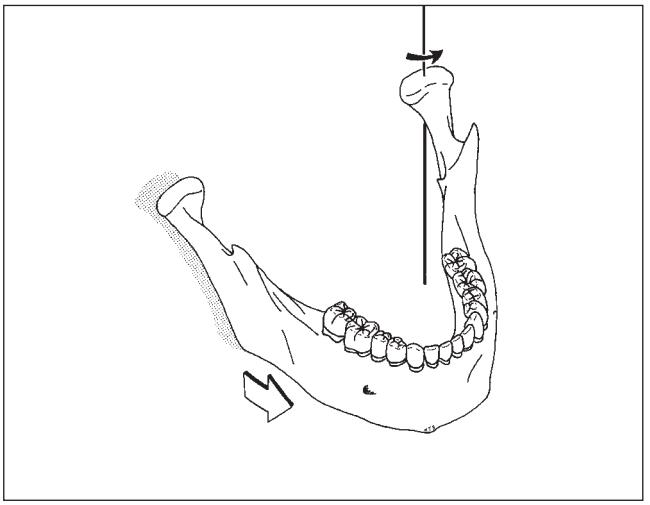

Fig 2-5 Mandibular movement occurs around a vertical axis during a lateral excursion.

Mandibular Movement

Mandibular movement can be broken down into a series of motions that occur around three axes:

1. *Horizontal axis* (Fig 2-4): This movement, in the sagittal plane, happens when the mandible in centric relation makes a purely rotational opening and closing border movement around the transverse horizontal axis, which extends through both condyles.
2. *Vertical axis* (Fig 2-5): This movement occurs in the horizontal plane when the mandible moves into a lateral excursion. The center for this rotation is a vertical axis extending through the rotating or working-side condyle.
3. *Sagittal axis* (Fig 2-6): When the mandible moves to one side, the condyle on the side opposite the direction of movement travels forward. As it does, it encounters the eminence of the glenoid fossa and moves downward simultaneously. When viewed in the frontal plane, this produces a downward arc on the side opposite the direction of movement, rotating around an anteroposterior (sagittal) axis passing through the other condyle.

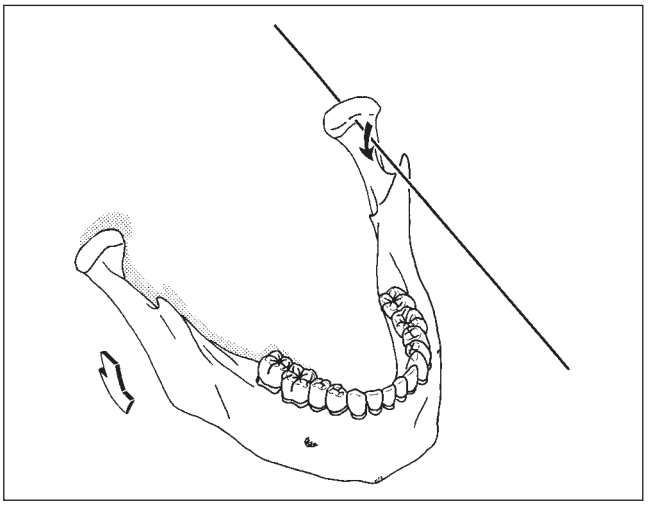

Fig 2-6 The mandible also rotates around a sagittal axis when one side drops down during a lateral excursion.

Various mandibular movements are composed of motions occurring concurrently around one or more of the axes. The up-and-down motion of the mandible is a combination of two movements. A purely hinge movement occurs as the result of the condyles rotating in the lower compartments of the TMJs within a 10- to 13-degree arc, which creates a 20- to 25-mm separation of the anterior teeth (see Fig 2-3b). This phenomenon was the basis for the terminal hinge axis theory in the early 1920s by McCollum.[3] Kohno verified the presence of a transverse horizontal axis, which he termed the *kinematic axis*.[13] There is also some gliding movement in the upper compartment of the joint if the mandible drops down farther (see Fig 2-3c). Then the axis of rotation shifts to the area of the mandibular foramen, as the condyles translate forward and downward while continuing to rotate.

When the mandible slides forward so that the maxillary and mandibular anterior teeth are in an end-to-end relationship, it is in a protrusive position. Ideally, the anterior segment of the mandible will travel a path guided by contacts between the anterior teeth, with complete disocclusion of the posterior teeth (Fig 2-7).

Mandibular movement to one side will place it in a working, or laterotrusive, relationship on that side and a nonworking, or mediotrusive, relationship on the opposite side; eg, if

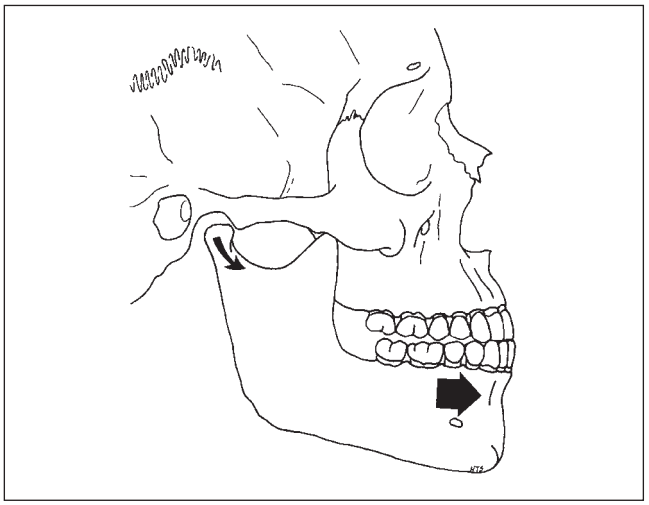

Fig 2-7 A protrusive movement occurs when the mandible moves forward.

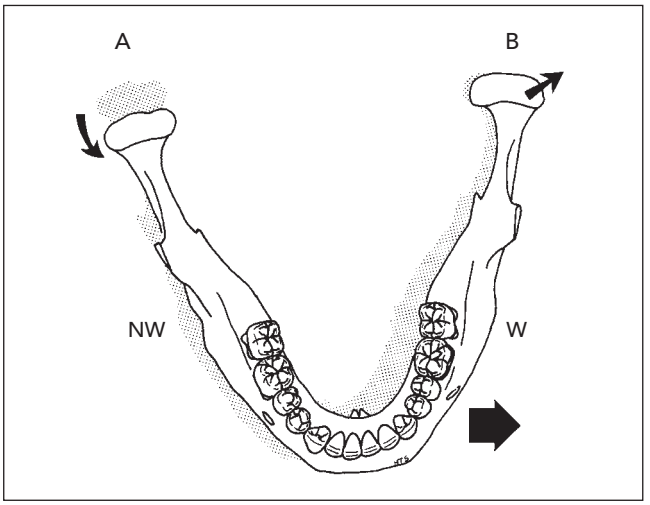

Fig 2-8 When the mandible moves into a left lateral excursion, the right condyle (A) moves forward and inward, while the left condyle (B) will shift slightly in a lateroposterior direction. In this example, the left side is the working side (W), and the right side is the nonworking side (NW).

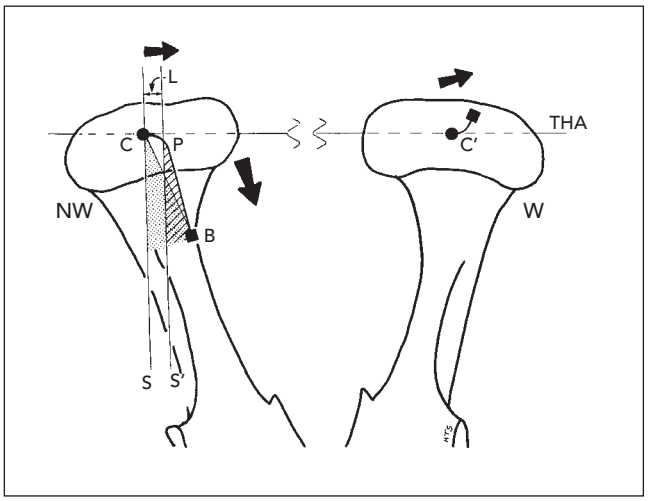

Fig 2-9 In the nonworking condyle (NW), the traditional Bennett angle (SCB) measures the angle from the sagittal plane to the endpoint of the movement of the condyle center. The Bennett angle used in articulators with an immediate lateral translation capability (S'PB) is measured from the sagittal plane after the immediate or early lateral translation (L) has occurred. The transverse horizontal axis (THA), or hinge axis of purely rotational movement, extends through both condyles. The working side condyle (W) slides laterally, or outward, in laterotrusion.

the mandible is moved to the left, the left side is the working side and the right side the nonworking side (Fig 2-8). In this type of movement, the condyle on the nonworking side will arc forward and medially (see A in Fig 2-8). Meanwhile, the condyle on the working side will shift laterally and usually slightly posteriorly (see B in Fig 2-8).

The bodily shift of the mandible in the direction of the working side was first described by Bennett.[14] The angle formed in the horizontal plane between the pathway of the nonworking condyle, the mandibular lateral translation, and the sagittal plane is called the *Bennett angle* (Fig 2-9). The presence of an immediate or early lateral translation, or side shift, has been reported in 86% of the condyles studied.[15] In addition to confirming the predominant presence of the early lateral translation, Lundeen and Wirth, using a mechanical apparatus, showed its median dimension to be approximately 1.0 mm with a maximum of 3.0 mm.[16] Hobo and Mochizuki, using an electronic measuring device, found a lower mean value of 0.4 mm for the immediate lateral translation, with a high of 2.6 mm.[17,18]

Following the immediate lateral translation, there is a further gradual shifting of the mandible, or progressive lateral translation, which occurs at a rate proportional to the forward movement of the nonworking condyle.[19] At one time, this was known as *progressive side shift* or *Bennett side shift*. Lundeen and Wirth found slight variation in the direction of the progressive lateral translation or Bennett angle, with a mean value of 7.5 degrees.[16] Hobo and Mochizuki found a much greater variation, ranging from 1.5 to 36 degrees, with a mean value of 12.8 degrees.[17,18]

Determinants of mandibular movement

The two condyles and the contacting teeth are analogous to the three legs of an inverted tripod suspended from the cranium. The determinants of the movements of that tripod are, posteriorly, the right and left TMJs; anteriorly, the teeth of the maxillary and mandibular arches; and overall, the neuromuscular system.[20]

The dentist has no control over the posterior determinants, the TMJs; they are unchangeable. However, they influence the movements of the mandible, and of the teeth, by the paths that the condyles must travel when the mandible is moved by the muscles of mastication. The measurement and reproduction of those condylar movements is the basis for the use of articulators.

The anterior determinant, the teeth, provides guidance to the mandible in several ways. The posterior teeth provide the vertical stops for mandibular closure. They also guide the mandible into the position of maximal intercuspation, which may or may not correspond with the optimum position of the condyles in the glenoid fossae. The anterior teeth (canine to canine) help to guide the mandible in right and left lateral excursive movements and in protrusive movements. Anterior teeth are especially suited for guidance by virtue of:

- Canines having the longest, strongest roots in their respective arches
- The load being reduced by distance from the fulcrum (Class III lever)
- The proprioceptive threshold and concomitant reflexes reducing the load[21–23]

Dentists have direct control over the tooth determinant by orthodontic movement of teeth; restoration of the anterior lingual or posterior occlusal surfaces; and equilibration, or selective grinding, of any teeth that are not in a harmonious relationship. Intercuspal position and anterior guidance can be altered, for better or for worse, by any of these means.

The closer a tooth is located to a determinant, the more it will be influenced by that determinant (Fig 2-10). A tooth located near the anterior region will be influenced greatly by anterior guidance and less by the TMJ. A tooth in the posterior region will be influenced partially by the joints and partially by anterior guidance.

The neuromuscular system, through proprioceptive nerve endings in the periodontium, muscles, and joints, monitors the position of the mandible and its paths of movement. Through reflex action, it will program the most physiologic paths of movement possible under the set of circumstances present. Dentists have indirect control over this determinant through procedures performed on the teeth, which may affect the response of the neuromuscular system.

One of the objectives of restorative dentistry is to place the teeth in harmony with the TMJs. This results in minimum stress on the teeth and joints, with only a minimum effort expended by the neuromuscular system to produce mandibular movements. When the teeth are not in harmony with the joints and the movements of the mandible, an interference is said to exist.

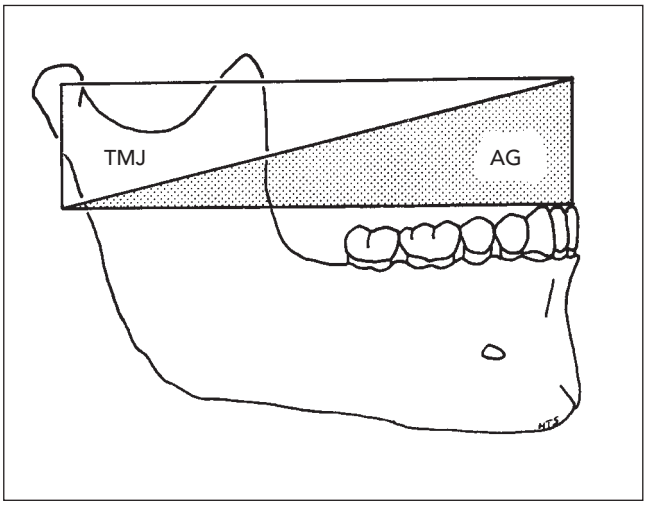

Fig 2-10 The farther anterior a tooth is located, the less the influence of the TMJ and the greater the influence of the anterior guidance (AG).

Occlusal interferences

Interferences are undesirable occlusal contacts that may produce mandibular deviation during closure to maximal intercuspation or may hinder smooth passage to and from the intercuspal position. There are four types of occlusal interferences:

1. Centric
2. Working
3. Nonworking
4. Protrusive

The *centric interference* is a premature contact that occurs when the mandible closes with the condyles in their optimum position in the glenoid fossae (Fig 2-11). It will cause deflection of the mandible in a posterior, anterior, and/or lateral direction.[24]

A *working interference* may occur when there is contact between the maxillary and mandibular posterior teeth on the same side of the arches as the direction in which the mandible has moved (Fig 2-12). If that contact is heavy enough to disocclude anterior teeth, it is an interference.[25]

A *nonworking interference* is an occlusal contact between maxillary and mandibular teeth on the side of the arches opposite the direction in which the mandible has moved in a lateral excursion (Fig 2-13). The nonworking interference is

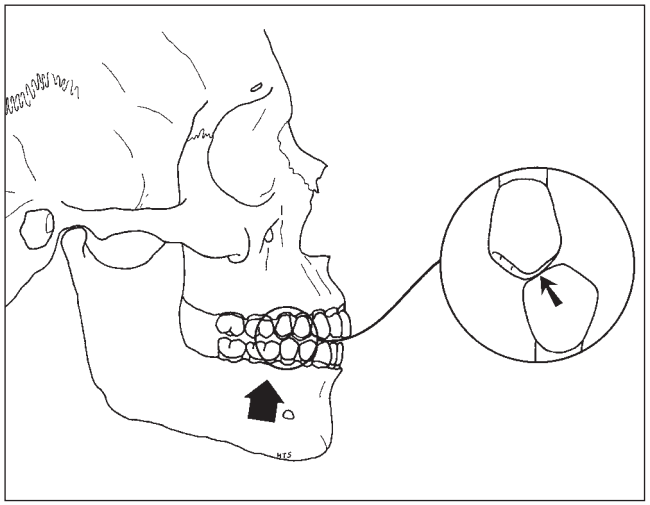

Fig 2-11 A centric occlusal interference often occurs during mandibular closure between maxillary mesial-facing cusp inclines and mandibular distal-facing inclines. As a result, the mandible is deflected anteriorly.

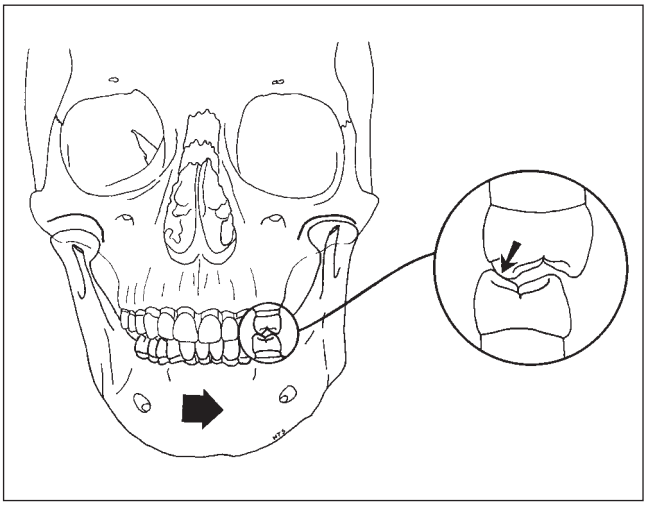

Fig 2-12 A working interference may occur between maxillary palatal-facing cusp inclines and mandibular facial-facing cusp inclines on the working side.

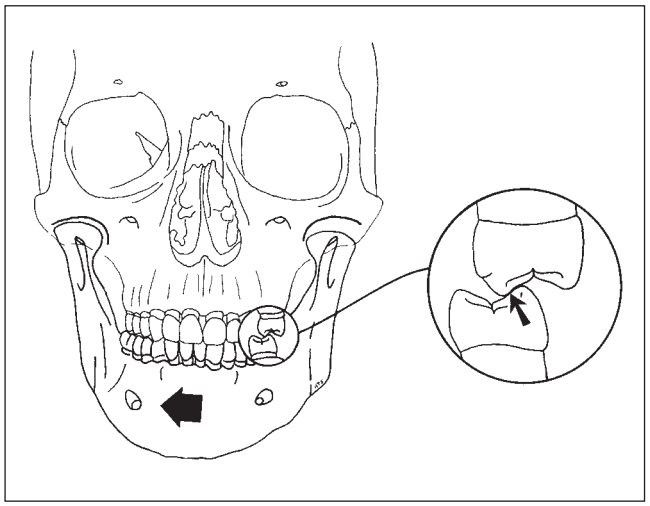

Fig 2-13 A nonworking interference results when there is contact between maxillary facial-facing cusp inclines and mandibular lingual-facing cusp inclines on the nonworking side.

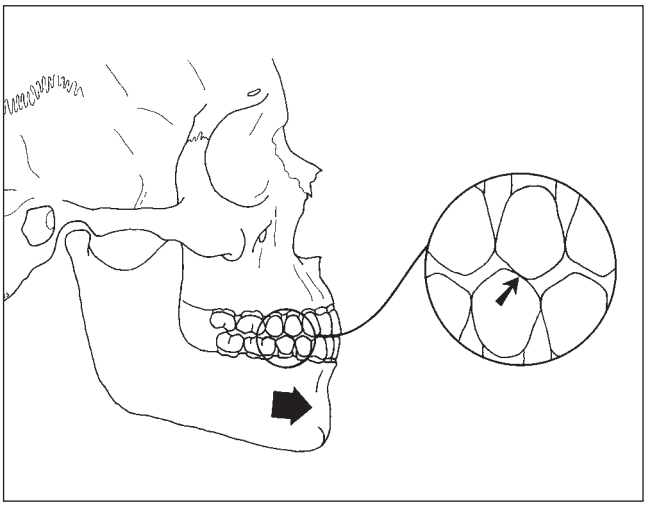

Fig 2-14 A protrusive interference occurs when distal-facing inclines of maxillary posterior teeth contact mesial-facing inclines of mandibular posterior teeth during a protrusive movement.

particularly destructive in nature.[26–29] The potential for damaging the masticatory apparatus has been attributed to changes in the mandibular leverage, the placement of forces outside the long axes of the teeth, and disruption of normal muscle function.[30]

A *protrusive interference* is a premature contact occurring between the mesial aspects of mandibular posterior teeth and the distal aspects of maxillary posterior teeth (Fig 2-14). Because of the proximity of the teeth to the muscles and the oblique vector of the forces, contacts between opposing posterior teeth during protrusion are potentially destructive and interfere with the patient's ability to incise properly.

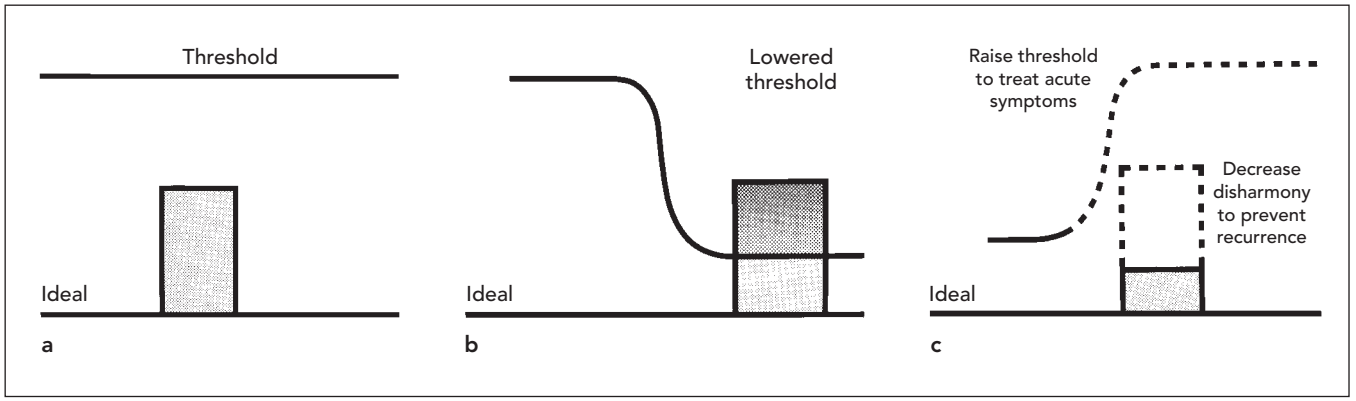

Fig 2-15 *(a)* There may be an occlusal disharmony *(shaded bar)* that is not ideal but is tolerated by the patient because it is below his or her threshold of perception and discomfort. *(b)* If the threshold is lowered, the disharmony that had been previously tolerated may produce symptoms in the patient. *(c)* Treatment is then rendered by first raising the patient's threshold and then decreasing or eliminating the disharmony.[33]

Normal versus pathologic occlusion

In only slightly more than 10% of the population is there complete harmony between the teeth and the TMJs.[31] This finding is based on a concept of centric relation in which the mandible is in the most retruded position. With the present concept of the condyles being in the most superoanterior position with the disc interposed, the results could be different. Nonetheless, in a majority of the population, the position of maximal intercuspation causes the mandible to be deflected away from its optimum position.

In the absence of symptoms, this can be considered physiologic, or normal. Therefore, in the normal occlusion there will be a reflex function of the neuromuscular system, producing mandibular movement that avoids premature contacts. This guides the mandible into a position of maximal intercuspation with the condyle in a less-than-optimal position. The result will be either some hypertonicity of nearby muscles or trauma to the TMJ, but it is usually well within most people's physiologic capacity to adapt and will not cause discomfort.

However, the patient's ability to adapt may be influenced by the effects of psychologic stress and emotional tension on the central nervous system.[32] An increase in the patient's stress level will frequently increase parafunctional jaw activity such as clenching or bruxing, and a normal occlusion can become a pathologic one[33–37] (Fig 2-15). Simple muscle hypertonicity may give way to muscle fatigue and pain, with chronic headaches and localized muscle tenderness, or TMJ dysfunction may occur. Pathologic occlusion can also manifest itself in the physical signs of trauma and destruction. Heavy facets of wear on occlusal surfaces, fractured cusps, and tooth mobility often are the result of occlusal disharmony. There is no evidence that occlusal trauma will produce a primary periodontal lesion. However, when occlusal trauma is present, there will be more severe periodontal breakdown in response to local factors than there would be if only the local factors were present.[38]

Habit patterns may develop in response to occlusal disharmony and emotional stress. Bruxism and clenching, the cyclic rubbing together of opposing occlusal surfaces, will produce even greater tooth destruction and muscle dysfunction.

When the acute discomfort of a patient with a pathologic occlusion has been relieved, changes that will prevent the recurrence of symptoms must be effected in the occlusal scheme. Care must also be taken when providing occlusal restorations for a patient without symptoms. The dentist must not produce an iatrogenic pathologic occlusion.

In the placement of restorations, the dentist must strive to produce an occlusion that is as nearly optimum as his or her skills and the patient's oral condition will permit. The optimum occlusion is one that requires minimal adaptation by the patient. The criteria for such an occlusion have been described by Okeson[39]:

- In closure, the condyles are in the most superoanterior position against the discs on the posterior slopes of the eminences of the glenoid fossae. The posterior teeth are in solid and even contact, and the anterior teeth are in slightly lighter contact.
- Occlusal forces are along the long axes of the teeth.
- In lateral excursions of the mandible, working-side contacts (preferably on the canines) disocclude or separate the nonworking teeth instantly.
- In protrusive excursions, anterior tooth contacts will disocclude the posterior teeth.
- In an upright posture, posterior teeth contact more heavily than do anterior teeth.