SIXTH
EDITION

CONTEMPORARY FIXED PROSTHODONTICS

STEPHEN F. ROSENSTIEL
MARTIN F. LAND
ROBERT D. WALTER

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PREFACE

Change is inevitable, but not always welcome. We were saddened to learn that our dear friend Junhei Fujimoto would not be able to continue his participation in the sixth edition of *Contemporary Fixed Prosthodontics*, in no small part because his in-depth knowledge and understanding, his outstanding clinical talents, and his superb educational skills contributed so much to each of the previous editions. The continuing explosion of new information again made a team effort imperative to ensure that this in-depth revision would enjoy the same outstanding reception the five previous editions consistently have enjoyed. Dr. Robert Walter graciously agreed to join in this so-elusive pursuit of excellence, and a highly enjoyable collaboration certainly helped elevate both content and quality to new levels.

A seasoned author once mused, "It is difficult for textbook authors, the presumed experts, to give the concise answers our students seek. It is difficult for us to be succinct, because a true teacher always seeks to provide 'the complete picture.' Simultaneously however, the student asking the question often still struggles to comprehend the underlying principles that we as faculty and educators base our answers on."

As authors and editors of the sixth edition, we certainly have been guilty of this in our academic and clinical careers, always striving to offer the comprehensive context. Yet, in an era of shrinking attention spans, information overload, and students inundated by the competing demands of other disciplines, dental educators continue their struggle to provide concise and relevant contemporary information while attempting to reinforce those underlying principles that will remain universally valid with time. This challenge is not new or unique: 60 years ago, in the preface of the first edition of *Modern Practice in Crown and Bridge Prosthodontics*, Dr. John F. Johnston wrote of his book, "Its purpose is to be comprehensive but not encyclopedic in scope." Throughout all editions of *Contemporary Fixed Prosthodontics*, we have consistently tried to emulate his objective. We embarked on this edition with the mission to concisely incorporate the principles underlying recently introduced technologies throughout the applicable chapters while eliminating selected content that may no longer have the extensive clinical application it once enjoyed, only to be confronted with the reality of the multitude of existing differences between educational programs at national and international levels.

Fixed prosthodontics continues to undergo change at a revolutionary pace, in part driven by advances in computer technologies. Throughout all editions, we have consistently championed a strong emphasis on the principles and development of an in-depth understanding of dental technologies and relevant basic sciences to permit optimal clinical decision making. However, recognizing that, for instance, real-time development of new CAD/CAM techniques occurs at a pace impossible for us to match in our writings, coupled with the ever continuing evolution of new materials, further complicated an already near impossible task: to break down content into bite-sized portions manageable for the novice to process while remaining informative and of interest for the advanced student, researcher, and clinician.

Accordingly, we condensed whenever possible, while striving for completeness of information. Selected "classic" content was eliminated, while every effort was made to balance contemporary and new technologies with some techniques that may be used less frequently in clinical practice but continue to be essential building blocks in the undergraduate and postdoctoral dental curricula.

The book retains its core organization of four sections, but changes have been made within that structure. In Part I, Planning and Preparation, information on risk assessment and assessment of sleep disorders, clinical photography, and digital smile design were added. The chapter "Principles of Occlusion" now includes detailed information of the various stages of internal derangements of the temporomandibular joint. Emphasis was given to minimally invasive procedures correlated with orthodontic procedures, while the chapter "Periodontal Considerations" was comprehensively updated and revised.

Part II, Clinical Procedures: Section I, now includes a discussion on nonretentive bonded restorations. The tooth preparation chapters place an emphasis on prerequisites for all-ceramic restorations, while content on classic partial coverage preparations has been reduced. The chapter on implant-supported restorations has been comprehensively revised to include additional digital diagnostic and planning techniques. Optical scanning techniques to capture natural tooth preparations and implants are now included in "Tissue Management, Scanning and Impressions," and the discussion on CAD/CAM interim restorations has been expanded.

Part III incorporates current methods of communication with the dental laboratory, and digital technologies for virtual casts and digital restoration design are comprehensively detailed, as are ceramic frameworks, pressed and CAD-on techniques. Part IV has been updated with an emphasis on adhesive luting agents and procedures, and new contemporary clinical cases are included at the conclusion of the text. The Dental Materials and Equipment Index has been eliminated, given the ease with which this information can be found on-line. Therefore, throughout all chapters, product infomation and equipment manufacturers have been incorporated. For a glossary of prosthodontic terms, we refer you to Ferro KJ, et al., eds. The glossary of prosthodontic terms. Ninth edition. *J Prosthet Dent*. 2017;117(5S):e1–e105, available at https://www.thejpd.org/article/S0022-3913(16)30683-7/fulltext.

We continue in our belief that it is critical for novice and experienced clinicians alike to have a thorough understanding of the many challenges faced by the dental laboratory technician. Without such it is nearly impossible to provide the best quality of service to our patients. An additional prerequisite

is true mastery of the fine motor skills so necessary to apply the principles that guide high quality clinical care. For decades, freshmen courses in dental anatomy and morphology have relied on waxing procedures to develop an understanding and knowledge of optimal anatomic tooth form. We observe that an additional and critical benefit of demanding students to perform such "sculpting" exercises is the development of the fine motor control that is a prerequisite to the proper execution of the many challenging procedures performed in fixed prosthodontics.

It has taken time and careful analysis to develop the blueprint for the sixth edition of *Contemporary Fixed Prosthodontics*, and as always, the decisions that were made undoubtedly will leave room for future improvement. This edition is again closer to what we originally envisioned when initially embarking on this effort about 40 years ago. We hope that it will continue to help advance a discipline we have come to love and respect, and it has been our privilege to make a contribution. We hope that the novice, graduate student, researcher, and experienced clinician alike will find this work helpful in their pursuit of excellence.

Stephen F. Rosenstiel
Martin F. Land
Robert D. Walter

ACKNOWLEDGMENTS

As before, our sixth endeavor to produce *Contemporary Fixed Prosthodontics* would not be possible without the substantial contributions from our colleagues and collaborators, especially Dr. Robert Walter becoming our third author and Ms. Krystyna Srodulski returning to produce her special illustrations.

Sadly, we mourn the loss of three special contributors. Mr. Jim Cockerill's expert photography provided many of the images in the previous editions, and his services were greatly missed for the current revision. If you look closely, you can see Jim's portrait in Fig. 27.28. Drs. M.H. Reisbick and James Sandrik both contributed their expertise in materials science. Dr. Reisbick was the department chair at The Ohio State University when the first edition was developed in the 1980s. His mentorship and encouragement was greatly appreciated and was fundamental to the success of the textbook. Dr. Sandrik headed a strong dental materials team at Loyola University. His expertise with scanning electron microscopy was pivotal to many of the image in the text. Their contributions continue into the current edition, and they are greatly missed.

Special thanks must be given to Dr. Ariel Raigrodski for his friendship and being instrumental in forming our team for the sixth edition. At Loma Linda University, Dr. Charles Goodacre is thanked for his mentorship. Drs. James Brudvik, John Townsend, and Ralph Yuodelis from the University of Washington must also be acknowledged for their support and sharing their vision of excellence in dentistry. It is impossible to thank all the world-class educators at the University of Washington with a few words, but the culture they created is held with reverence in many hearts.

Once again, we acknowledge the contributions of our colleagues. At Ohio State, Dr. Shereen Azer contributed his innovative approach to recording mandibular movement via computed tomography in Chapter 2, and we thank our friend Dr. Jim Metz for his contribution on the assessment of sleep-disordered breathing in Chapter 1. Dr. Burak Yilmaz, now in Bern, Switzerland, revised the chapters "Implant-Supported Fixed Prostheses" and "Tissue Management, Scanning, and Impression Making." Colleagues at Southern Illinois University Edwardsville, Drs. Jack Marincel, Christa Hopp, Duane Douglas, Minaal Verma, and Rick Biethman, all made substantial contributions, with revisions to the chapters "Principles of Occlusion," "Periodontal Considerations," "Mouth Preparation," "Tooth Preparation for Ceramic Restorations," and "Pontic Design." At the University of Connecticut, Drs. Tom Taylor and John Agar are thanked for their friendship and support, as is Dr. Avinash Bidra for his contributions to the chapter "Treatment Planning."

New contributors who greatly enhanced the textbook include Mr. Lee Culp, CDT, whose knowledge and insight of all things digital transformed "Restoration Design," and Mr. Harald Heindl, CDT, and Ms. Daniela Heindl made substantial contributions to the chapter "Communicating With the Dental Laboratory." Furthermore, Mr. Heindl also provided laboratory support with his mastery in ceramics in many photographs in Chapters 7, 8, 26, and 28. Other substantial contributions were made by Dr. Pooya Soltanzadeh, who updated "Luting Agents and Cementation Procedures." At the Loma Linda University School of Dentistry, we thank Dr. Montry Suprono, who invested his time in revising "Retainers for Partial Removable Dental Prostheses," and Drs. Mathew Kattadiyil and Abdulaziz Alzaid for their contributions to "Definitive Casts and Dies." Gratitude must also be given to Drs. Van Ramos for his contribution to the chapter "Interim Fixed Restorations," Dr. Xavier Lepe, who supplied images for the digital post and core, and Dr. Dick Tucker who provided photographs of his cast gold restorations, all from the University of Washington.

Once again, we are indebted to the Elsevier group, including our Senior Content Development Specialist, Ann Anderson, and our Senior Project Manager, Doug Turner. Both have provided meticulous support with patience and understanding. Of course, errors and omissions remain the responsibility of the authors. We also extend special appreciation to the many dental manufacturers that provided excellent illustrations and advice on their products.

It is impossible for anyone text to include all of the answers, but we have tried once again to present the current state of the art of fixed prosthodontics in the hope that our efforts may help advance the undoubtedly most demanding of clinical dental specialties. Anyone with a true interest in achieving mastery in our field should be able to find many, if not most, of the answers they seek.

Stephen F. Rosenstiel
Martin F. Land
Robert D. Walter

CONTENTS

1

History Taking and Clinical Examination

Fixed prosthodontic treatment involves the replacement and restoration of teeth by artificial substitutes that are not readily removable from the mouth. Its focus is to restore function, esthetics, and comfort. Fixed prosthodontics can offer exceptional satisfaction for both patient and dentist. It can transform an unhealthy, unattractive dentition with poor function into a comfortable, healthy occlusion capable of years of further service while greatly enhancing esthetics (Fig. 1.1A and B). Treatment can range from fairly straightforward measures—such as restoration of a single tooth with a ceramic crown (see Fig. 1.1C), replacement of one or more missing teeth with a fixed dental prosthesis (see Fig. 1.1D), or an implant-supported restoration (see Fig. 1.1E)—to highly complex restorations involving all the teeth in an entire arch or the entire dentition (see Fig. 1.1F).

To achieve predictable success in this technically and intellectually challenging field, meticulous attention to every detail is crucial: the initial patient interview and diagnosis, the active treatment phases, and a planned schedule of follow-up care. Otherwise, the result is likely to be unsatisfactory and frustrating for both dentist and patient, resulting in disappointment and loss of confidence in each other.

Problems encountered during or after treatment can often be traced to errors and omissions during history taking and initial examination. The inexperienced dentist may plunge into the treatment phase before collecting sufficient diagnostic information that helps to predict likely pitfalls.

Making the correct diagnosis is prerequisite for formulating an appropriate treatment plan. All pertinent information must be obtained. A complete history includes a comprehensive assessment of the patient's general and dental health, individual needs, preferences, and personal circumstances. This chapter is a review of the fundamentals of history taking and clinical examination, with special emphasis on obtaining the necessary information to make appropriate decisions about fixed prosthodontic treatment.

HISTORY

A patient's history should include all pertinent information concerning the reasons for seeking treatment, along with any personal information, including relevant previous medical and dental experiences. The chief complaint should be recorded, preferably in the patient's own words. A screening questionnaire (Fig. 1.2) is useful for history taking; it should be reviewed in the patient's presence to correct any mistakes and to clarify inconclusive entries. If the patient is mentally impaired or a minor, the guardian or responsible parent must be present.

Chief Complaint

The accuracy and significance of the patient's primary reason or reasons for seeking treatment should be analyzed first. These may be just the obvious features, and careful examination often reveals problems and disease of which the patient is unaware; nevertheless, the patient perceives the chief complaint as the major or only important problem. Therefore, when a comprehensive treatment plan is proposed, special attention must be given to how the chief complaint can be resolved. The inexperienced dentist who tries to prescribe an "ideal" treatment plan can easily lose sight of the patient's wishes. The patient may then become frustrated because the dentist does not appear to understand or does not want to understand the patient's point of view.

Chief complaints usually belong to one of the following four categories:

- Comfort (pain, sensitivity, swelling)
- Function (difficulty in mastication or speech)
- Social (bad taste or odor)
- Appearance (fractured or unattractive teeth or restorations, discoloration)

Comfort

If pain is present, its location, character, severity, and frequency should be noted, as well as the first time it occurred, what factors precipitate it (e.g., pressure, hot, cold, or sweet things), any changes in its character, and whether it is localized or more diffuse in nature. It is often helpful for the patient to point at the area while the dentist pays close attention.

If swelling is present, the location, size, consistency, and color are noted, as well as how long it has been felt and whether it is increasing or decreasing.

Function

Difficulties in mastication may result from a local problem such as a fractured cusp or missing teeth; they may also indicate a more generalized malocclusion or neuromuscular dysfunction.

Fig. 1.1 (A) Severely damaged maxillary dentition. (B) Restoration with metal-ceramic fixed prostheses. (C) Tooth supported zirconia three-unit fixed partial denture opposing implant-supported and tooth-supported zirconia crowns. (D) Three-unit fixed dental prosthesis that replaces missing mandibular premolar. (E) Congenitally missing maxillary lateral incisors replaced with implant supported crowns. (F) Extensive fixed prosthodontics involving restoration of multiple teeth. (D, Courtesy Dr. J. Nelson. E, Courtesy Dr. A. Hsieh.)

Social Aspects

A bad taste or smell often indicates compromised oral hygiene and periodontal disease. Social pressures prompt many affected patients to seek care.

Appearance

Compromised appearance is a strong motivating factor for patients to seek advice as to whether improvement is possible (Fig. 1.3). Such patients may have missing or crowded teeth, or a tooth or restoration may be fractured. The teeth may be unattractively shaped, malpositioned, or discolored, or there may be a developmental defect. A single discolored tooth may indicate pulpal disease.

Personal Details

The patient's name, address, phone number, sex, occupation, work schedule, marital status, and budgetary flexibility are noted. Much can be learned in a 5-minute, casual conversation during the initial visit. In addition to establishing rapport and developing a basis on which the patient can trust the dentist,

HEALTH QUESTIONNAIRE

REG. NO. _____

Name _____ Date _____ Age _____

Write Yes or No.

1. Have you been hospitalized or under the care of a physician within the last 2 years? _____
2. Has there been a change in your general health within the past 2 years? _____
3. Are you allergic to penicillin or any other drugs? _____
4. Indicate **Yes** or **No** to any of the conditions below for which you are being or have been treated:

Y / N	Heart attack	Y / N	Hives, skin rash	Y / N	Substance abuse
Y / N	Heart trouble	Y / N	Cancer treatment	Y / N	AIDS
Y / N	Heart surgery	Y / N	Radiation therapy	Y / N	HIV infection
Y / N	Angina (chest pain)	Y / N	Ulcers	Y / N	Diabetes
Y / N	High blood pressure	Y / N	Gastritis	Y / N	Hepatitis
Y / N	Prolapsed mitral valve	Y / N	Hiatus hernia	Y / N	Kidney trouble
Y / N	Heart murmur	Y / N	Easy bruising	Y / N	Psychiatric treatment
Y / N	Artificial heart valves	Y / N	Excessive bleeding	Y / N	Fainting spells
Y / N	Congenital heart lesions	Y / N	Artificial joint	Y / N	Seizures
Y / N	Cardiac pacemaker	Y / N	Arthritis	Y / N	Epilepsy
Y / N	Rheumatic fever	Y / N	Asthma	Y / N	Anemia
Y / N	Stroke	Y / N	Persistent cough		
Y / N	Allergies	Y / N	Emphysema		

Women only

Y / N Currently pregnant
Y / N Nursing
Y / N Female problems

Do you use tobacco? Y / N Type _____ How much? _____

Do you drink alcohol? Y / N Type _____ How much? _____

5. Have you had any serious illness, disease, or condition not listed above? _____
   If so, explain _____
6. Indicate date of your last physical examination _____
7. Name and address of your personal physician _____
8. List any medications you are currently taking _____
9. Have you had any problems or anxiety associated with previous dental care? _____
   If so, explain _____

DENTAL QUESTIONNAIRE

Indicate Yes or No to the following:

Y / N 10. Does it hurt when you chew?
Y / N 11. Is a tooth sensitive or tender?
Y / N 12. Do you have frequent toothaches or gum pain?
Y / N 13. Do your gums bleed a lot when you brush your teeth?
Y / N 14. Do you have occasional dryness or burning in your mouth?
Y / N 15. Do you have occasional pain in the jaws, neck, or temples?
Y / N 16. Does it hurt when you open wide or take a big bite?
Y / N 17. Does your jaw make "clicking or popping" sounds when you chew or move your jaw?
Y / N 18. Do you suffer from headaches?
Y / N 19. Do you have occasional ear pain or pain in front of the ears?
Y / N 20. Does your jaw "feel tired" after a meal?
Y / N 21. Do you ever have to search for a place to close your teeth?
Y / N 22. Does a tooth ever get in the way?

23. Is there anything you wish to tell us that has not been asked?
24. Were there any items you did not understand?

I will inform the Clinic of any changes in the above

Person completing form sign here: _____

self parent guardian

Circle relationship
If minor: parent or legal guardian signature

Date signed: _____

Fig. 1.2 Screening questionnaire.

small and seemingly unimportant personal details often have considerable influence in establishing a correct diagnosis, prognosis, and treatment plan.

Medical History

An accurate and current general medical history should include any medications the patient is taking and all relevant medical conditions. If necessary, the patient's physician or physicians can be contacted for clarification. The following classification may be helpful:

1. Conditions affecting the treatment methods (e.g., any disorders that necessitate the use of antibiotic premedication, any use of steroids or anticoagulants, and any previous allergic responses to medication or dental materials). Once such conditions are identified, treatment usually can be modified as part of the comprehensive treatment plan, although some conditions may severely limit available options.
2. Conditions affecting the treatment plan (e.g., previous radiation therapy, hemorrhagic disorders, extremes of age, and terminal illness). These can be expected to affect the patient's response to dental treatment and may influence the prognosis. For instance, patients who have previously received radiation treatment in the area of a planned extraction require special measures to prevent serious complications.
3. Systemic conditions with oral manifestations. For example, periodontitis may be exacerbated by diabetes, menopause, pregnancy, or the use of anticonvulsant drugs (Fig. 1.4); in patients with gastroesophageal reflux disease, bulimia, or anorexia nervosa, teeth may be eroded by regurgitated stomach acid (Fig. 1.5)[1,2]; certain drugs may generate side effects that mimic temporomandibular disorders[3] or reduce salivary flow.[4,5]
4. Possible risks to the dentist and auxiliary personnel (e.g., patients who are suspected or confirmed carriers of hepatitis B, acquired immunodeficiency syndrome, or syphilis).

Dental offices practice "universal precautions" to ensure appropriate infection control. This means that full infection control is practiced for every patient; no additional measures are needed when dentists treat known disease carriers.[6]

Fig. 1.3 Poor appearance is a common reason for seeking restorative dental treatment.

Fig. 1.4 Severe gingival hyperplasia associated with anticonvulsant drug use. (Courtesy Dr. P.B. Robinson.)

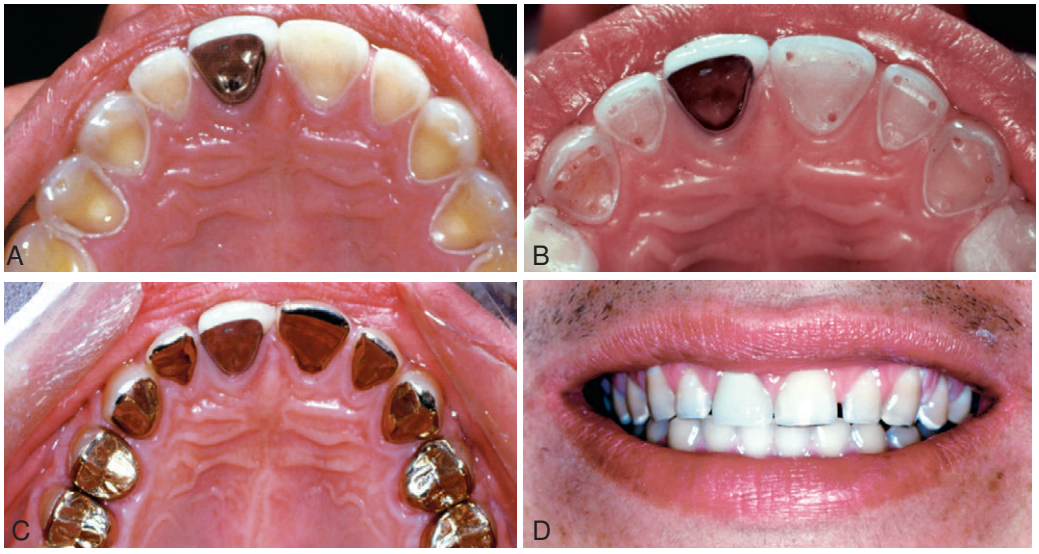

Fig. 1.5 (A) Extensive damage caused by self-induced acid regurgitation. Note that the lingual surfaces are bare of enamel except for a narrow band at the gingival margin. (B) Teeth prepared for partial-coverage restorations. (C and D) The completed restoration.

Dental History

Dentists should complete a thorough examination before establishing a diagnosis. With adequate experience, a dentist can often assess preliminary treatment needs during the initial appointment, but review and analysis of additional diagnostic information are frequently necessary (see Chapter 2). In addition, assessing the quality of a previously rendered treatment fairly can be difficult because the circumstances under which the treatment was rendered are seldom known. When such an assessment is requested for legal proceedings, the patient should be referred to a specialist familiar with the "usual and customary" standard of care.

Periodontal History

The patient's oral hygiene is assessed, and current plaque-control measures are discussed, as are previously received oral hygiene instructions. The frequency of any previous debridement should be recorded, and the dates and nature of any previous periodontal surgery should be noted.

Restorative History

The patient's restorative history may include only simple composite resin or dental amalgam fillings, or it may involve crowns and extensive fixed dental prostheses. The age of existing restorations can help to establish the prognosis and probable longevity of any future fixed prostheses.

Endodontic History

Patients often forget which teeth have been endodontically treated. These can be readily identified with radiographs. The findings should be reviewed periodically so that periapical health can be monitored and any recurring lesions promptly detected (Fig. 1.6).

Orthodontic History

Occlusal analysis should be an integral part of the assessment of dentition after orthodontic treatment. If restorative treatment needs are anticipated, the restorative dentist should perform the occlusal evaluation. Occlusal adjustment (reshaping of the occlusal surfaces of the teeth) may be needed to promote long-term positional stability of the teeth and to reduce or eliminate parafunctional activity (see Chapter 6). On occasion, root resorption (detected on radiographs) (Fig. 1.7) may be attributable to previous orthodontic treatment. Because this may affect the crown-to-root ratio, future prosthodontic treatment and its prognosis may also be affected. Restorative treatment can often be simplified by minor tooth movement. In orthodontic treatment, considerable time can be saved if minor tooth movement (for restorative reasons) is incorporated from the start. Thus good communication between the restorative dentist and the orthodontist may prove very helpful.

Removable Prosthodontic History

The patient's experiences with removable prostheses must be carefully evaluated. For example, a partial removable dental prosthesis may not have been worn for a variety of reasons, and the patient may not even mention its existence. Careful questioning and examination usually elicit discussion concerning any such devices. Listening to the patient's comments about previously unsuccessful removable prostheses can be very helpful in assessing whether future treatment will be more successful.

Oral Surgical History

The dentist must obtain information about missing teeth and any complications that may have occurred during tooth removal. Special evaluation and data collection procedures are necessary for patients who require prosthodontic care after orthognathic surgery. Before any treatment is undertaken, the prosthodontic component of the proposed treatment must be fully coordinated with the surgical component.

Radiographic History

Previously made radiographs may prove helpful in judging the progress of dental disease. They should be obtained if possible. Dental practices usually forward radiographs or acceptable duplicates promptly on request. In most instances, however, a current diagnostic radiographic series is essential and should be obtained as part of the examination.

Fig. 1.6 Defective endodontic treatment has led to recurrence of a periapical lesion. Re-treatment is required.

Fig. 1.7 Apical root resorption after orthodontic treatment.

Myofascial Pain and Temporomandibular Joint Dysfunction History

Myofascial pain, clicking in the temporomandibular joints (TMJs), or neuromuscular symptoms, such as abnormal muscle tone or tenderness to palpation, should be treated and resolved before fixed prosthodontic treatment begins. A screening questionnaire efficiently identifies patients with these symptoms who may be at higher risk for complications. Such patients should be questioned regarding any previous treatment for joint dysfunction (e.g., occlusal devices, medications, biofeedback, or physical therapy exercises).

EXAMINATION

In an examination, the dentist uses sight, touch, and hearing to detect abnormal conditions. To avoid mistakes, it is critical to record what is actually observed rather than to make diagnostic comments about the condition. For example, "swelling," "redness," and "bleeding on probing of gingival tissue" should be recorded, rather than "gingival inflammation" (which implies a diagnosis).

Thorough examination and data collection are needed for prospective patients who desire fixed prosthodontic treatment, and more detailed protocols for this effort can be obtained from various textbooks of oral diagnosis.[7,8]

General Examination

The patient's general appearance, gait, and weight are assessed. Skin color is noted, and vital signs, such as respiration, pulse, temperature, and blood pressure, are measured and recorded. Middle-aged and older patients can be at higher risk for cardiovascular disease. Relatively inexpensive cardiac monitoring units are available for in-office use (Fig. 1.8). Patients whose vital sign measurements are outside normal ranges should be referred for a comprehensive medical evaluation before definitive prosthodontic treatment is initiated.

Extraoral Examination

Special attention is given to facial asymmetry because small deviations from normal may hint at serious underlying conditions. Cervical lymph nodes are palpated, as are the TMJs and the muscles of mastication.

Temporomandibular Joints

The dentist locates the TMJs by palpating bilaterally just anterior to the auricular tragi while the patient opens and closes the mouth. This enables a comparison between the relative timing of left and right condylar movements during the opening stroke. Asynchronous movement may indicate a disk displacement that prevents one of the condyles from making a normal translatory movement (see Chapter 4). Auricular palpation (Fig. 1.9) with

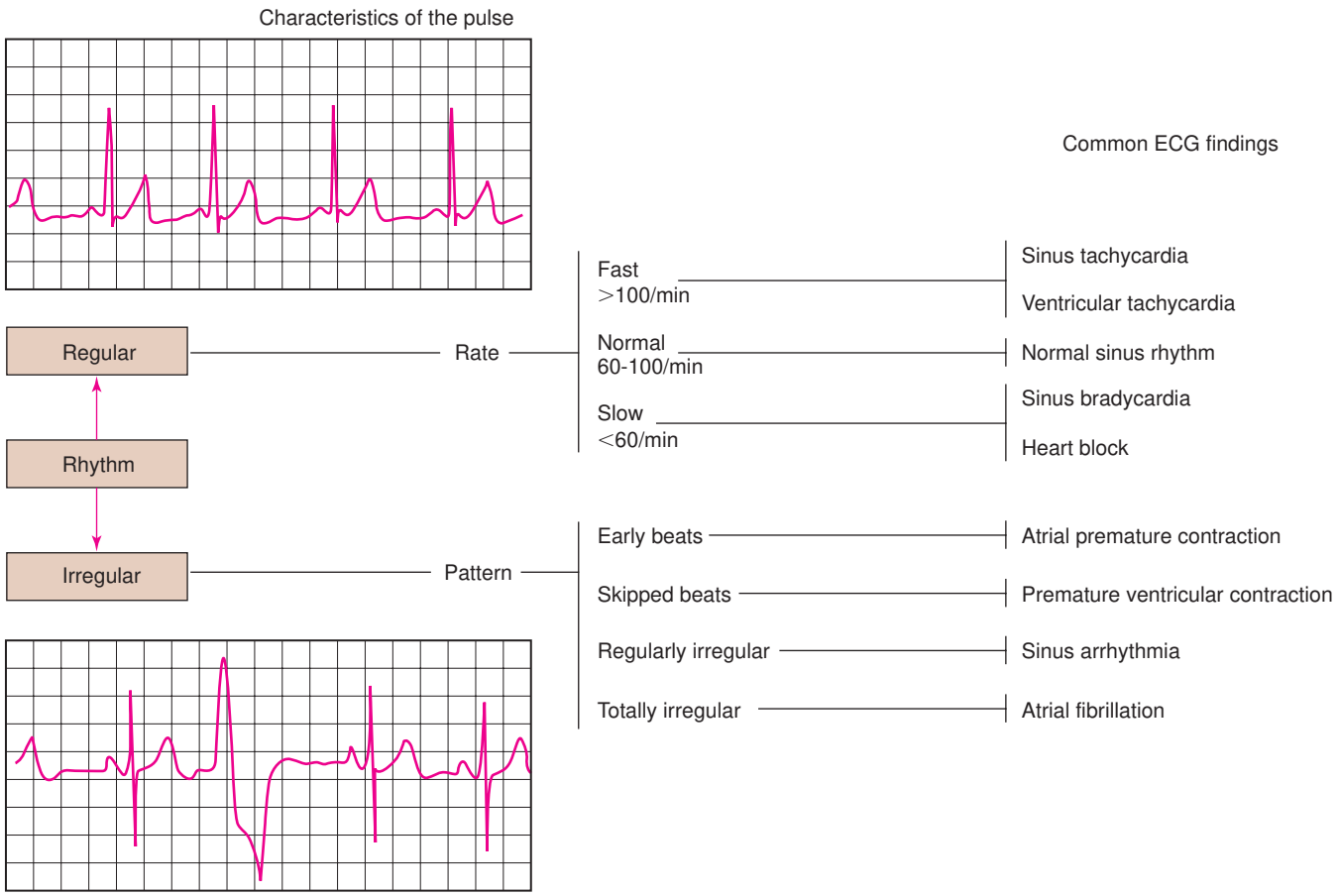

Fig. 1.8 Cardiac monitoring printout and representative electrocardiography findings. (Courtesy Dr. T. Quilitz.)

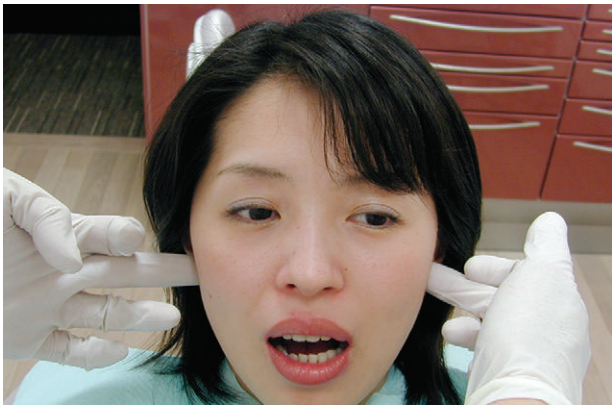

Fig. 1.9 Auricular palpation of the posterior aspects of the temporomandibular joints.

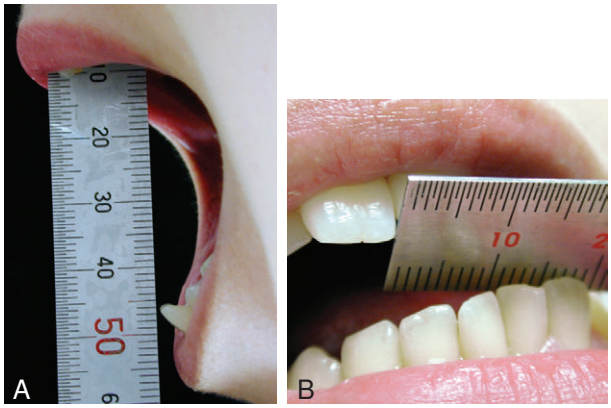

Fig. 1.10 Maximum opening of more than 50 mm (A) and lateral movement of approximately 12 mm (B) are normal.

light anterior pressure may help to identify potential disorders in the posterior attachment of the disk. Tenderness or pain on movement is noted and can be indicative of inflammatory changes in the retrodiscal tissues, which are highly vascular and innervated. Clicking in the TMJ is often noticeable through auricular palpation but is difficult to detect by palpating directly over the lateral pole of the condylar process because the overlying tissues can muffle the click. Placing the fingertips on the angles of the patient's mandible permits identification of even a minimal click because very little soft tissue lies between the clinician's fingertips and the mandibular bone.

Joint abnormalities may also be identified by evaluating the patient's occlusal relationship in the fully seated condylar position (FSCP). This is done by hinging the patient's mandible with bimanual manipulation (see also Chapter 2), until the initial point of tooth contact, which is recorded. If in a growing child or adolescent a greater than 2-mm Angle class II relationship is observed and a 2-mm separation of the lower incisal edge is present (measured from where "normal" cingulum contact occurs), an internal derangement with disc dislocation (Piper IV—see Chapter 4) may be present on the deficient side. Although this is also true for adult patients, such may be more difficult to diagnose because adaptations may have occurred in the anterior region such as supraeruption of teeth. If the presence of any pathologies is suspected or uncertain, the following should be recorded: first molar and canine and Angle classification, open occlusal relationship, reverse articulation, magnitude, and direction of any midline deviations (see Chapter 4), and any gross arch discrepancies.

A maximum mandibular opening resulting in less than 35 mm of interincisal movement is considered restricted, because the average opening is greater than 50 mm.[9,10] Such restricted movement on opening can be indicative of intracapsular changes in the joints. Similarly, any midline deviation on opening or closing is recorded. The maximum lateral movements of the patient can be measured (normal is approximately 12 mm) (Fig. 1.10).

Muscles of Mastication

Muscle palpation can provide helpful insight, although it provides information of only the status quo, at the time of examination. Following examination of the TMJs and the evaluation of range of motion, the masseter and temporal muscles and other relevant postural muscles are palpated for signs of tenderness (Fig. 1.11). Palpation is best accomplished bilaterally and simultaneously. This allows the patient to compare and report any differences between the left and right sides. Light pressure should be used (the amount of pressure that can be tolerated without discomfort on one's closed eyelid is a good comparative measure), and if any difference is reported between the left and right sides, the patient is asked to classify the discomfort as mild, moderate, or severe. If there is evidence of significant asynchronous movement or TMJ dysfunction, the dentist should follow a systematic sequence for comprehensive muscle palpation as described by Solberg[9] and Krogh-Poulsen and Olsson.[11] Each palpation site is scored numerically on the basis of the patient's response. If neuromuscular or TMJ treatment is initiated, the examiner can then repalpate the same sites periodically to assess the response to treatment (Fig. 1.12).

Lips

The patient is observed for tooth visibility during normal and exaggerated smiling. This can be critical in the planning of fixed prosthodontic treatment,[12] especially when the need to fabricate crowns or fixed dental prostheses is anticipated in the esthetic zone. Some patients show only their maxillary teeth during smiling. More than 25% do not show the gingival third of the maxillary central incisors during an exaggerated smile (Fig. 1.13).[13] The extent of the smile depends on the length and mobility of the upper lip and the length of the alveolar process. When the patient laughs, the jaws open slightly and a dark space is often visible between the maxillary and mandibular teeth (Fig. 1.14). This has been called the *negative space*.[14] Missing teeth, diastemas, and fractured or poorly restored teeth disrupt the harmony of the negative space and often must be corrected (see Chapter 23).[15]

Screening for Sleep-Disordered Breathing

James E. Metz

Many signs and symptoms may be recognizable in dental patients.[16] The medical history may show presence of comorbid conditions such as hypertension or other cardiovascular disease, hyperlipidemia, or type 2 diabetes mellitus.[16–21] Dental and clinical examination may exhibit presence of a worn dentition;

Fig. 1.11 Muscle palpation of the masseter (A), the temporal muscle (B), the trapezius muscle (C), the sternocleidomastoid muscle (D), and the floor of the mouth (E).

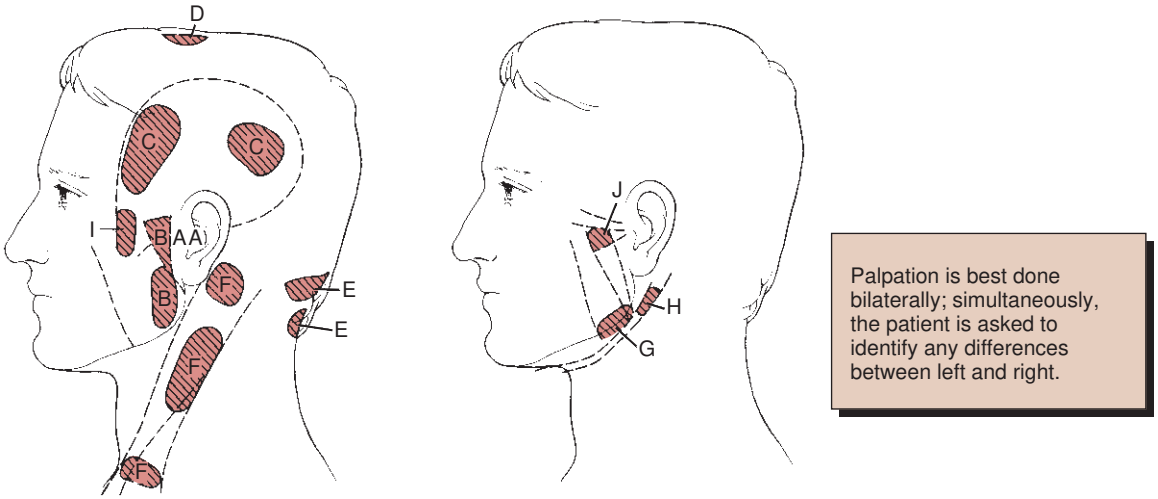

Fig. 1.12 Palpation sites for assessing muscle tenderness. *A*, Temporomandibular joint capsule: lateral and dorsal. *B*, Masseter: deep and superficial. *C*, Temporal muscle: anterior and posterior. *D*, Vertex. *E*, Neck: nape and base. *F*, Sternocleidomastoid muscle: insertion, body, and origin. *G*, Medial pterygoid muscle. *H*, Posterior digastric muscle. *I*, Temporal tendon. *J*, Lateral pterygoid muscle. (From Krogh-Poulsen WG, Olsson A. Occlusal disharmonies and dysfunction of the stomatognathic system. *Dent Clin North Am*. 1966;10:627).

Fig. 1.13 Smile analysis is an important part of the examination, particularly when anterior crowns or fixed dental prostheses are being considered. (A) Some individuals show considerable gingival tissue during an exaggerated smile. (B) Others may not show the gingival margins of even the central incisors. (C) This individual shows little tooth when smiling.

Fig. 1.14 The "negative space" between the maxillary and mandibular teeth is assessed during the examination.

missing teeth; tongue scalloping; enlarged palatine tonsils, tongue, or soft palate; and a high Mallampati or Friedman score.[16,22–28] Lateral cephalometric radiographs can also provide data indicative of an airway issue, including airway length; hyoid bone position; upper and lower face heights; and excessive soft tissues including tongue, velum, and lymphoid tissue.[29–31] Questionnaires can be used to screen dental patients for potential sleep-related breathing disorders (SRBDs). More than 100 surveys, questionnaires, and scales are available for use.[32] The STOP-Bang, Berlin Questionnaire, and Epworth Sleepiness Scale (ESS) can be useful to assess an individual's risk for sleep-disordered breathing in undiagnosed subjects, as well as to track improvement of symptoms through a course of treatment.[33–35]

These surveys should not be relied upon as the sole screening method; those with severe obstructive sleep apnea (up to 100 events per hour of sleep) may exhibit no daytime symptoms and score zero on the ESS.[36] Therefore it is critical to have an objective method for screening in combination with report of subject symptoms to discern which individuals warrant referral to a sleep medicine physician for definitive medical diagnosis. Dental professionals can use high-resolution pulse oximetry to screen for SRBDs. A wrist- and finger-worn device can be easily dispensed to the recall patient, eliminating wait time for an appointment in an overnight sleep laboratory. Such a device is inexpensive compared with a full-montage polysomnogram and can be run for multiple nights to rule out anomalous events. It can eliminate the "first night effect," by allowing for testing in the home sleep environment, and may overcome night-to-night variation in respiratory events.[37–44] High-resolution pulse oximetry data may indicate a high likelihood of an SRBD, and the findings are highly correlated to polysomnography, warranting referral for medical diagnosis and allowing for initiation of therapy.[45–47]

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Intraoral Examination

The intraoral examination can reveal considerable information concerning the condition of the soft tissues, teeth, and supporting structures. The tongue, floor of the mouth, vestibule, cheeks, and hard and soft palates are examined, and any abnormalities are noted. This information can be evaluated properly during treatment planning only if objective indices, rather than vague assessments, are used.

Periodontal Examination

Robert F. Baima

In a periodontal examination,[48] the clinician evaluates the status of bacterial accumulation, the response of the host tissues, and the degree of reversible and irreversible damage. Long-term periodontal health is prerequisite for successful fixed prosthodontics (see Chapter 5). Existing periodontal disease must be corrected before any definitive prosthodontic treatment is undertaken.

Gingiva

The gingiva is dried for the examination so that moisture does not obscure subtle changes or detail. Color, texture, size, contour, consistency, and position are noted. The gingiva is carefully palpated to express any exudate present in the sulcular area.

Healthy gingiva (Fig. 1.15A) is pink, stippled, and firmly bound to the underlying connective tissue. The free gingival margin is knife-edged, and sharply pointed papillae fill the interproximal spaces. Any deviation from these findings is noted. With the development of chronic marginal gingivitis (see Fig. 1.15B), the gingiva becomes enlarged and bulbous, stippling is lost, the margins and papillae are blunted, and bleeding and exudate are observed.

To assess the width of the band of attached keratinized gingiva around each tooth, the clinician measures the width of the surface band of keratinized tissue in an apicocoronal dimension with a periodontal probe and subtracts the measurement of the sulcus depth. Alternatively, the marginal gingiva can be gently depressed with the side of a periodontal probe or explorer.

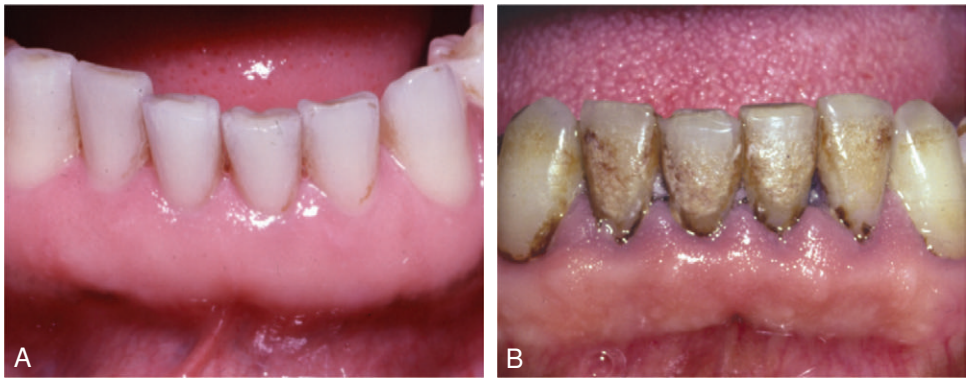

Fig. 1.15 (A) Healthy gingiva is pink, knife-edged, and firmly attached. (B) In gingivitis, plaque and calculus cause marginal inflammation, with changes in color, contour, and consistency of the free gingival margin. In this case, inflammation extends into the keratinized attached gingiva.

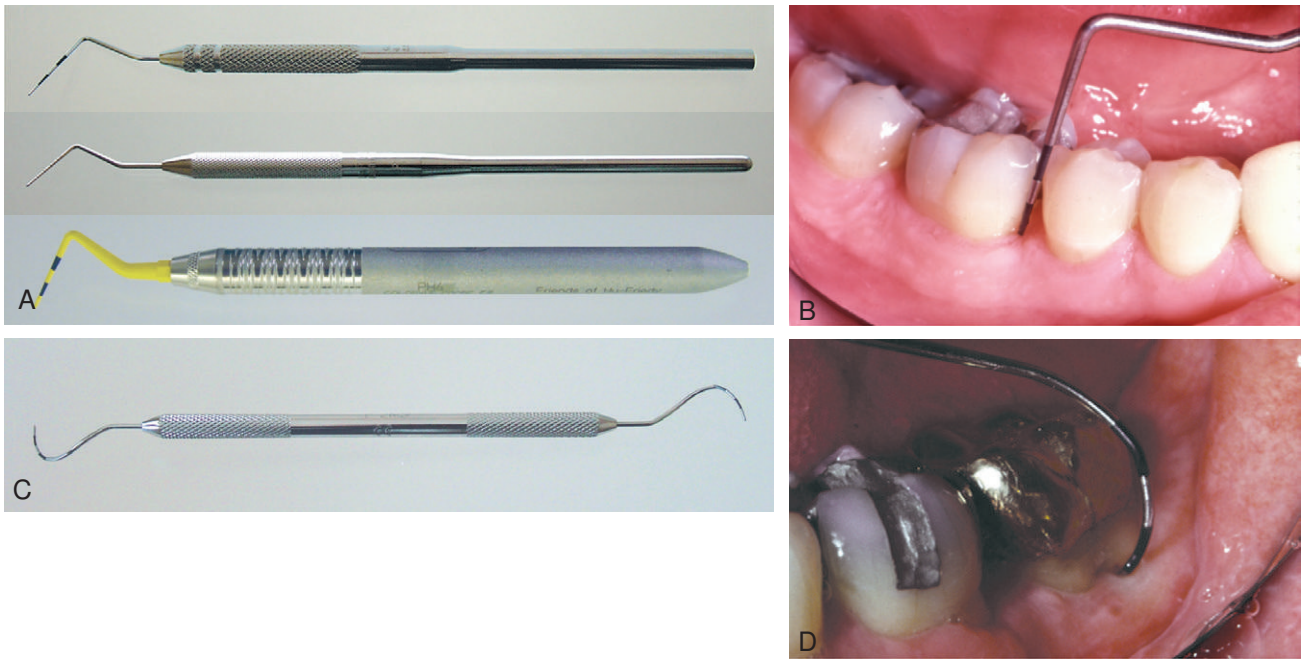

Fig. 1.16 (A) Three types of sulcus/pocket-measuring probes. (B) Correct position of a periodontal probe in the interproximal sulcular area, parallel to the root surface and in a vertical direction as far interproximally as possible. (C and D) Graduated furcation probe. (A and C, From Boyd LB. *Dental Instruments*. 5th ed. St. Louis: Saunders; 2015.)

At the mucogingival junction (MGJ), the effect of the instrument is seen to end abruptly, indicating the transition from tightly bound gingiva to more flexible mucosa. A third technique is to inject anesthetic solution into the nonkeratinized mucosa close to the MGJ to make the mucosa balloon slightly.

Periodontium

The periodontal probe (Fig. 1.16A) provides a measurement (in millimeters) of the depth of periodontal pockets and healthy gingival sulci. The probe is inserted essentially parallel to the tooth and is "walked" circumferentially through the sulcus in firm but gentle steps; the examiner determines the measurement when the probe is in contact with the apical portion of the sulcus (see Fig. 1.16B). Thus any sudden change in the attachment level can be detected. The probe may also be angled slightly (5 to 10 degrees) interproximally to reveal the topography of an existing lesion. Probing depths (usually six per tooth) are recorded on a periodontal chart (Fig. 1.17), which also contains other data such as tooth mobility or malposition, open proximal contact areas, inconsistent marginal ridge heights, missing or impacted teeth, areas of inadequate attached keratinized gingiva, gingival recession, furcation involvements, and malpositioned frenum attachments.

Clinical Attachment Level

Documenting the level of epithelial attachment helps the clinician to quantify periodontal destruction and is essential for rendering a diagnosis of periodontitis (loss of connective tissue attachment).[49,50] This measurement also provides objective information

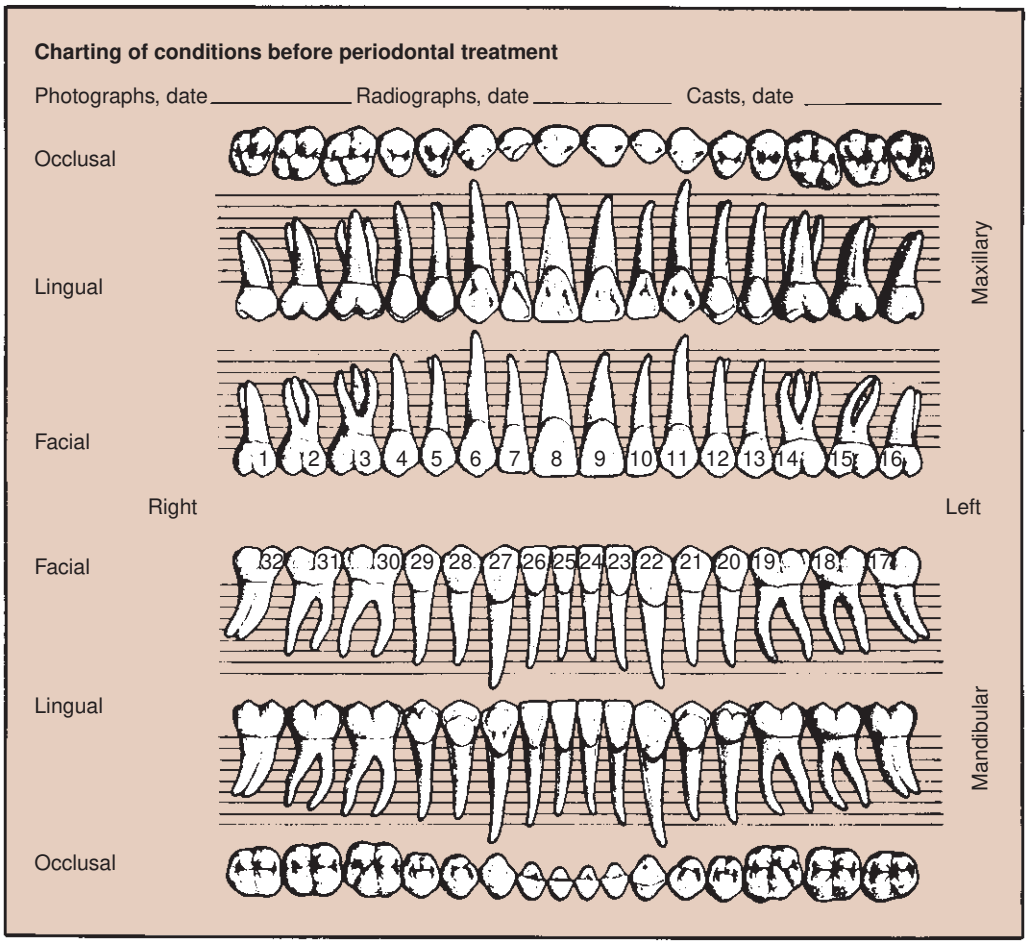

Fig. 1.17 Chart for recording pocket depths. The parallel lines are approximately 2 mm apart. The notations involved in using the chart are as follows: *1*, Block out any missing teeth. *2*, Draw a red × through the crown of any tooth that is to be extracted. *3*, Record the gingival level with a continuous *blue* line. *4*, Record pocket depths with a *red* line interrupted at the proximal surfaces of each tooth. *5*, Shade the pocket form on each tooth with a *red* pencil (between the *red* and *blue* lines). *6*, Indicate bifurcation or trifurcation involvements with a small red × at the involved area. *7*, Record open contacts with vertical parallel lines (||) through the area. *8*, Record improper contacts with a wavy red line through the area. *9*, Record gingival overhang(s) with a red spur (∧) through the area. *10*, Outline cavities and faulty restorations of periodontal significance in *red*. *11*, Indicate rotated teeth by outlining in *blue* to show their actual position. (Modified from Goldman HM, Cohen DW. *Periodontal Therapy*. 5th ed. St. Louis: Mosby; 1973.)

regarding the prognosis of individual teeth. The clinical attachment level is determined by measuring the distance between the apical extent of the probing depth and a fixed reference point on the tooth, most commonly either the apical extent of a restoration or the cementoenamel junction (CEJ). This is recorded on modified periodontal charts (Fig. 1.18). When the free margin of the gingiva is located on the clinical crown and the level of the epithelial attachment is at the CEJ, there is no attachment loss, and recession is noted as a negative number. When the attachment level is on root structure and the free gingival margin is at the CEJ, attachment loss equals the probing depth, and the recession is scored 0. When increased periodontal destruction and recession are present, attachment loss equals the probing depth plus the measurement of recession (see Fig. 1.18B and C).[51] Clinical attachment loss is a measure of periodontal destruction at a site, rather than of current disease activity; it may be considered the diagnostic standard for periodontitis[52] and should be documented in the initial periodontal examination.[53] It is an important consideration in the development of the overall diagnosis, treatment plan, and the prognosis of the dentition.

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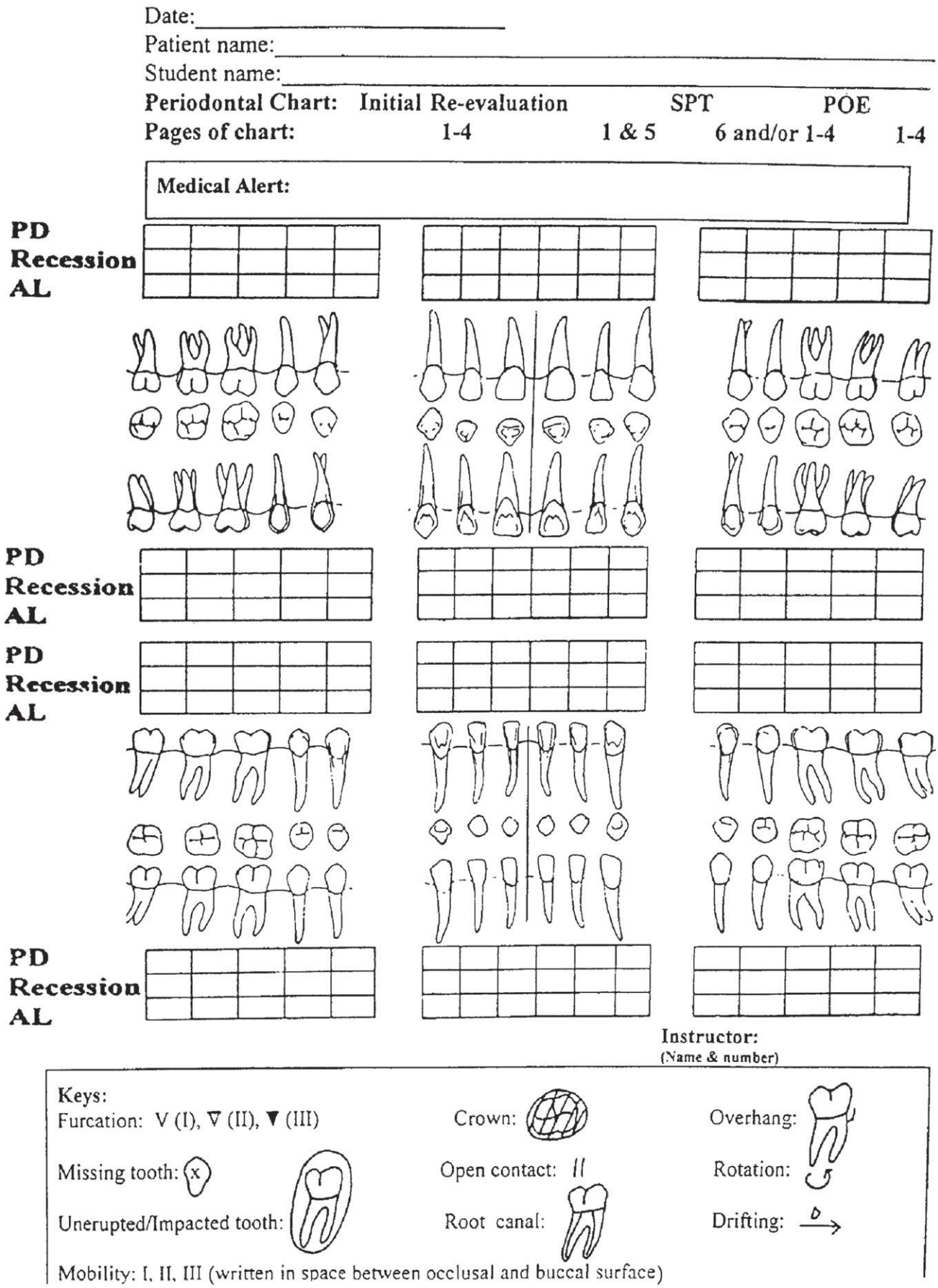
Dental Charting

An accurate charting of the state of the dentition reveals important information about the condition of the teeth and facilitates treatment planning. Adequate charting (Fig. 1.19) shows the presence or absence of teeth, dental caries, restorations, wear faceting and abrasions, fractures, malformations, and erosions. Tooth loss often affects the position of adjacent teeth (see Treatment of Tooth Loss section, Chapter 3). The presence of caries on one interproximal surface should prompt the examiner to carefully inspect the adjacent proximal surface, even if caries is not apparent radiographically. The degree and extent of caries development over time can have a considerable effect on the eventual outcome of fixed prosthodontic treatment. The condition and type of the existing restorations



A

Fig. 1.18 (A) Modified periodontal chart.

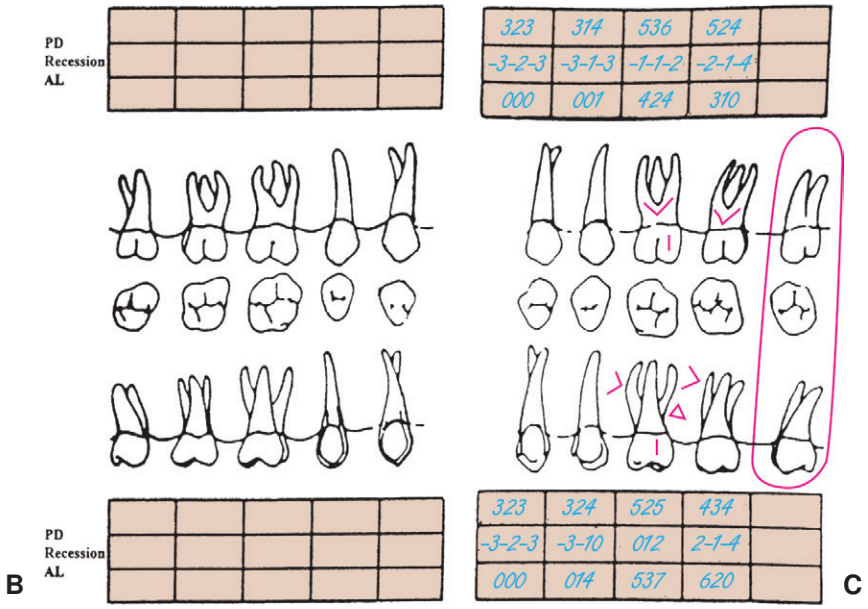


Fig. 1.18 Cont'd (B) Maxillary right sextant of modified periodontal chart with areas to record probing depths *(PD)*, recession, and attachment loss *(AL)*. (C) Maxillary left sextant of modified periodontal chart exhibiting clinical documentation. (Courtesy University of Detroit Mercy School of Dentistry, Department of Periodontology and Dental Hygiene, Detroit.)

are noted (e.g., amalgam, cast gold, composite resin, ceramic). Open contacts and areas where food impaction occurs must also be identified. The presence of wear facets is indicative of sliding contact sustained over time and thus may indicate parafunctional activity (see Chapter 4). However, wear facets are often easier to see on diagnostic casts (see Chapter 2); during the clinical examination, the location of any observed facet is recorded. Fracture lines in teeth may necessitate fixed prosthodontic intervention, although minor hairline cracks in walls that are not subject to excessive loading can often go untreated and simply be observed at recall appointments (see Chapter 31). The location of fractures and any other abnormalities should be recorded.

Occlusal Examination

The dentist starts the occlusal examination by asking the patient to make a few simple opening and closing movements, which the dentist carefully observes. The objective is to determine to what extent the patient's occlusion differs from the ideal (see Chapter 4) and how well the patient has adapted to any difference that may exist. Special attention is given to initial contact, tooth alignment, eccentric occlusal contacts, and jaw maneuverability.

Initial tooth contact. The relationship of teeth in both centric relation (CR) (see Chapter 4) and the maximum intercuspation (MI) should be evaluated. If all teeth come together simultaneously at the end of terminal hinge closure, the CR position of the patient is said to coincide with the MI (see also Chapters 2 and 4). The patient is guided into a terminal hinge closure to detect where initial tooth contact occurs (see also the sections on bimanual manipulation and terminal hinge closure in Chapters 2 and 4). The dentist should ask the patient to "close feather-light" until any of the teeth touch and to have the patient help identify where that initial contact occurs by asking him or her to point at the location. If initial contact occurs between two posterior teeth (usually molars), the subsequent movement from the initial contact to the MI position is carefully observed and its direction noted. This is referred to as a *slide from CR to MI*. The presence, direction, and estimated length of the slide are recorded, and the teeth on which initial contact occurs are identified. Any such discrepancy between CR and MI should be evaluated in the context of other signs and symptoms that may be present: for example, abnormal muscle tone previously observed during the extraoral examination, mobility (noted during the periodontal evaluation) on the teeth where initial contact occurs, and any wear facets on the teeth contacting during the slide.

General alignment. Any crowding, rotation, supraeruption, spacing, malocclusion, and vertical and horizontal overlap (Fig. 1.20) are recorded. In many cases, teeth adjacent to edentulous spaces have shifted slightly. Even minor tooth movement can significantly affect fixed prosthodontic treatment. Tipped teeth affect tooth preparation design or may necessitate minor tooth movement before restorative treatment. Supraerupted teeth are easily overlooked clinically but frequently complicate fixed dental prosthesis design and fabrication.

The relative relationship of adjacent teeth to planned fixed prostheses is important. A tooth may have drifted into the space previously occupied by the tooth in need of treatment because a large filling was lost for some time. Such changes in alignment can seriously complicate or preclude fabrication of a cast restoration for the damaged tooth and may even necessitate its extraction (see Fig. 1.20B).

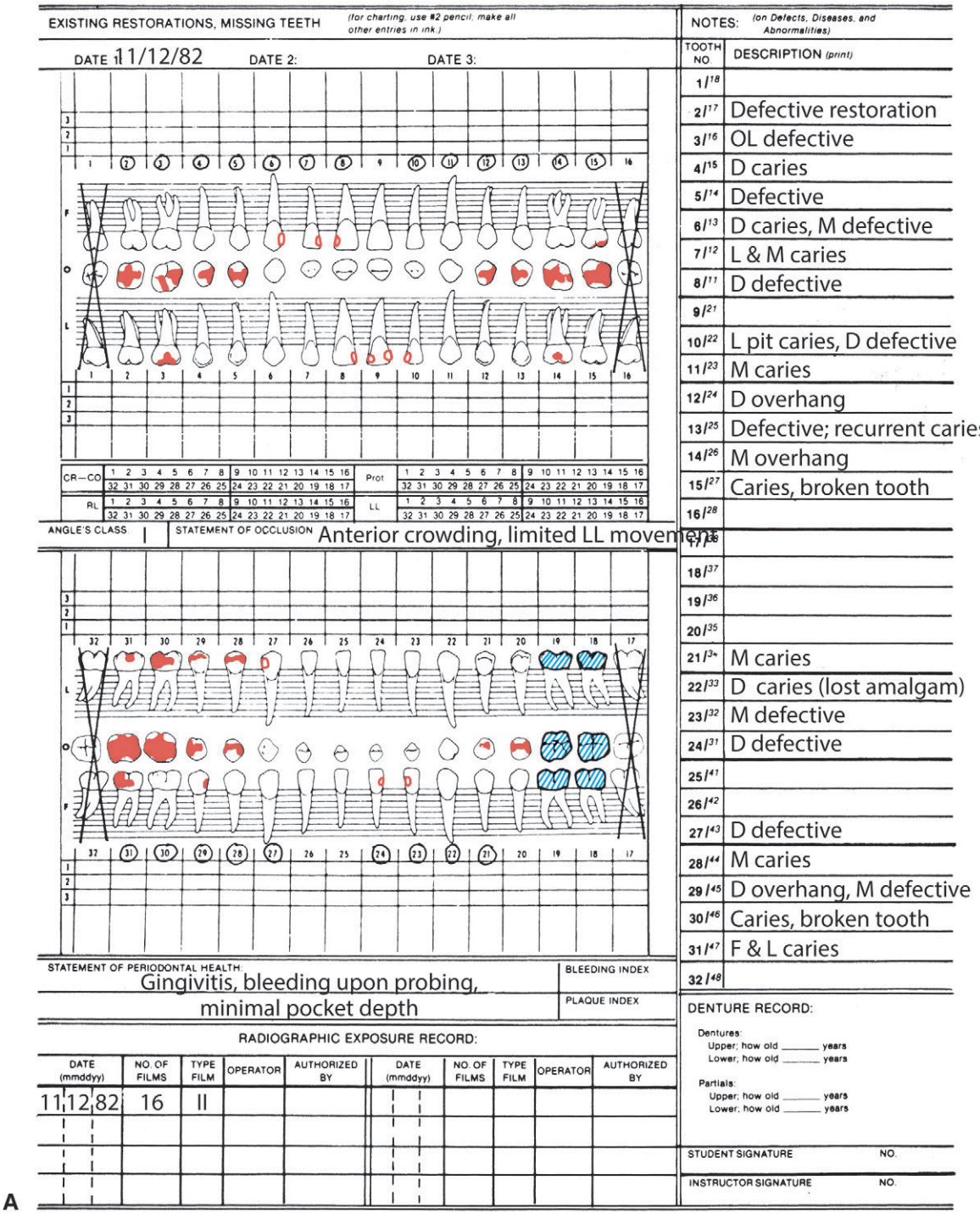


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Fig. 1.19 (A) An appropriate charting system designates the location, type, and extent of existing restorations and the presence of any disease condition, all of which become part of the patient's permanent record.

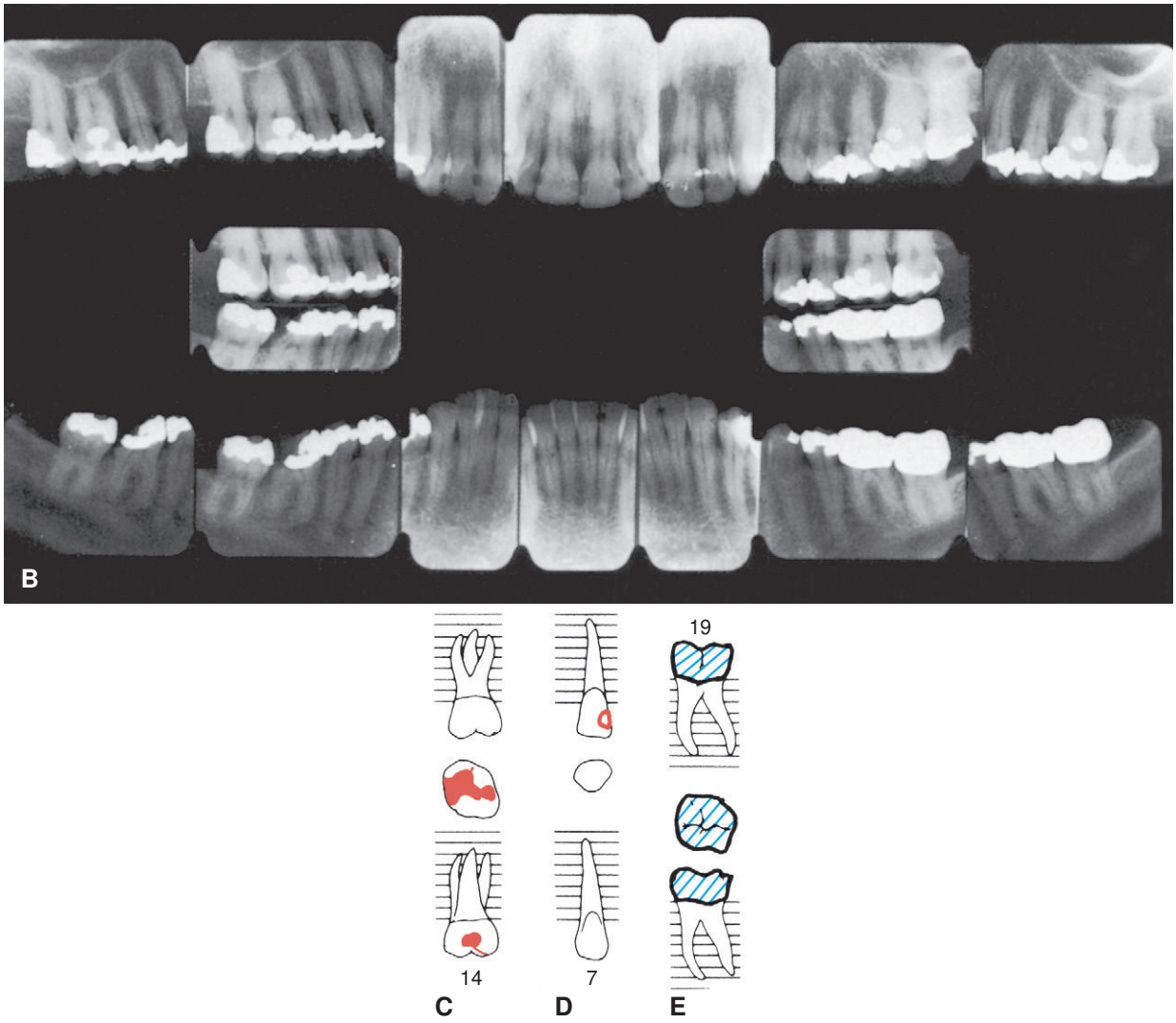

Fig. 1.19 Cont'd (B) Radiographic findings obtained from a full-mouth series are compared with the clinical findings and noted in the record. Charting is performed to provide a quick reference to conditions in the mouth. The following may be useful: (1) Amalgam restorations (C) are depicted by an outline drawing blocked in solidly to show the size, shape, and location of the restoration. (2) Tooth-colored restorations (D) are depicted by an outline drawing of the size, shape, and location of the restoration. (3) Gold restorations (E) are depicted by an outline drawing inscribed with diagonal lines to show the size, shape, and location of the restoration. (4) Missing teeth are denoted by a large *X* on the facial, lingual, and occlusal diagrams of each tooth that is not visible clinically or on radiographs. (5) Caries is recorded by circling the tooth number at the apex of the involved tooth and noting the presence and location of the cavity in the description column corresponding to the tooth number on the right. (6) Defective restorations are recorded by circling the tooth number and noting the defect in the description column. (Modified from Roberson T, et al. *The Art and Science of Operative Dentistry*. 4th ed. St. Louis: Mosby; 2002.)

Lateral and Protrusive Contacts

The degree of vertical and horizontal overlap of the teeth is noted. When asked, most patients are capable of making an unguided protrusive movement. During this movement, the degree of posterior disclusion that results from the overlaps of the anterior teeth is observed. Excursive contacts on posterior teeth may be undesirable (see Chapter 4).

The patient is then guided into lateral excursive movements, and the presence or absence of contacts on the nonworking side and then the working side is noted. Such tooth contact in eccentric movements can be verified with a thin Mylar strip (shim stock). Any posterior cusps that hold the shim stock are evident (Fig. 1.21). Teeth subjected to excessive loading may develop varying degrees of mobility. Tooth movement (fremitus) should be confirmed by palpation (Fig. 1.22). If excessive occlusal contact is suspected, a finger placed against the buccal or labial surface while the patient lightly taps the teeth together helps locate fremitus in MI.

Fig. 1.20 Alignment of the dentition can be assessed intraorally, although diagnostic casts allow a more detailed assessment. (A) This set of teeth is free of caries and in good alignment. (B) Poor vertical alignment: the mandibular molar is supraerupted, which has resulted in marginal ridge height discrepancy.

Fig. 1.21 Thin mylar shim stock (A) can be used to test eccentric tooth contact (B).

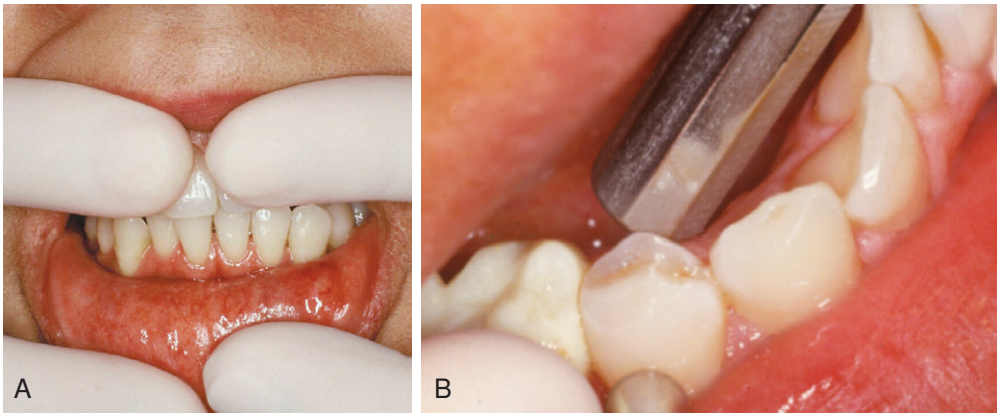

Fig. 1.22 (A) Fremitus (movement on palpation) indicates tooth contact during lateral excursions. (B) Mobility is tested by exerting horizontal force on the tooth between the handles of two instruments.

Jaw Maneuverability

The ease with which the patient moves the jaw and the way the mandible can be guided through hinge closure and excursive movements should be evaluated because this information is useful for assessing neuromuscular and masticatory function. If the patient has developed a pattern of protective reflexes, manipulating the jaw in a reproducible hinge movement can be difficult or impossible. Any restriction in maneuverability is recorded. A patient may move relatively freely in one lateral excursion but have difficulty moving to the contralateral side. Such limitation in maneuverability should be considered in the context of comprehensive occlusal and neuromuscular analysis (see Chapters 4 and 6).

Radiographic Examination

Digital radiographs provide essential information to supplement the clinical examination. Detailed knowledge of the extent of bone support and the root structure of each standing tooth is critical for establishing a comprehensive fixed prosthodontic treatment plan. According to radiation exposure guidelines, the number of radiographs should be limited to only those that will result in potential changes in treatment decisions; however, a full periapical series (Fig. 1.23) is normally required for new patients so that a comprehensive fixed prosthodontic treatment plan can be developed.

Panoramic films (Fig. 1.24) provide useful information about the presence or absence of teeth. They are especially

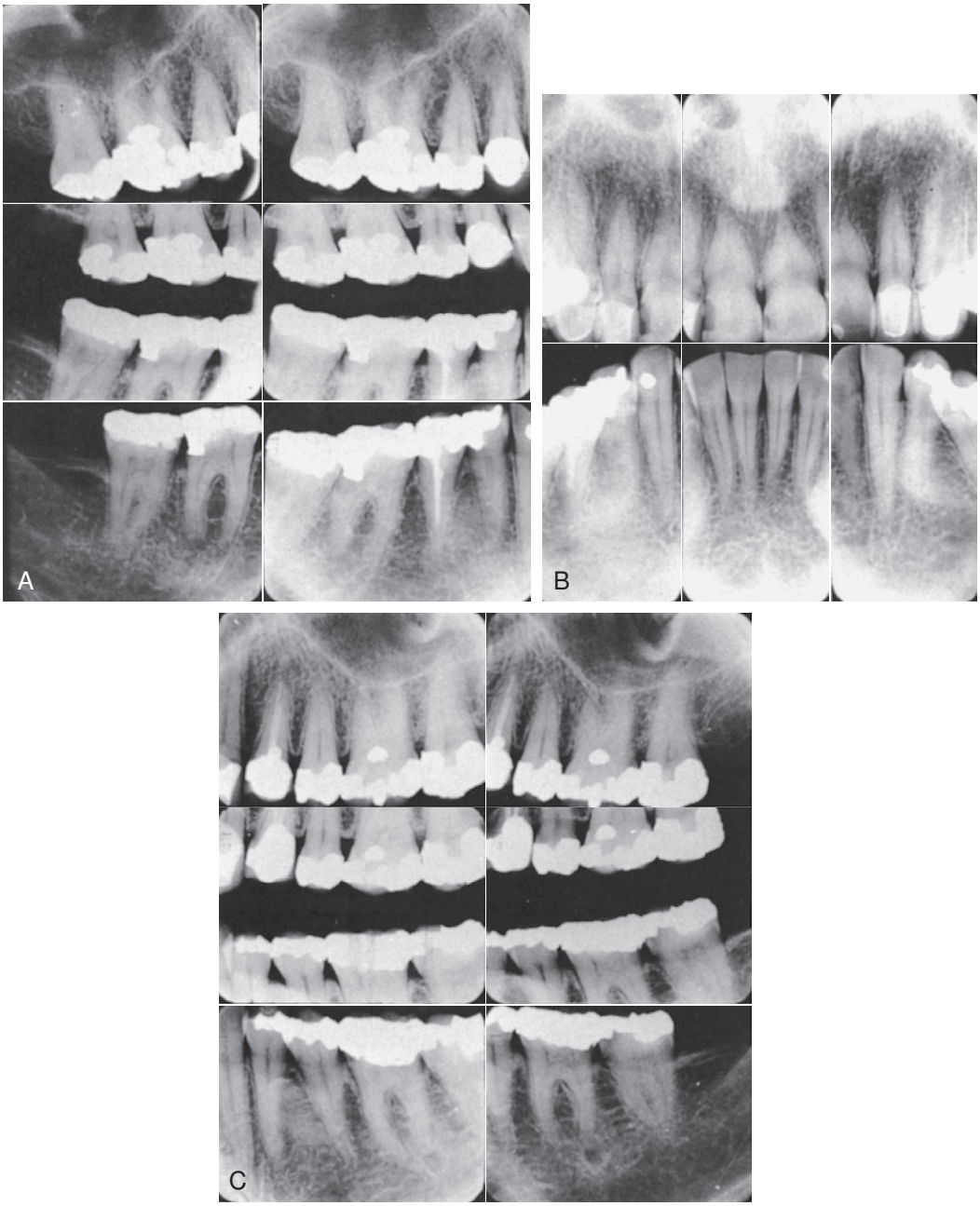

Fig. 1.23 (A–C) A full-mouth radiographic survey should enable the dentist to make a detailed assessment of the structure of each tooth and its bone support.

Fig. 1.24 A panoramic film cannot be substituted for a full-mouth series because the image is distorted. Nevertheless, it is very useful for assessing unerupted teeth, screening edentulous areas for buried root tips, and evaluating the bone before implant placement.

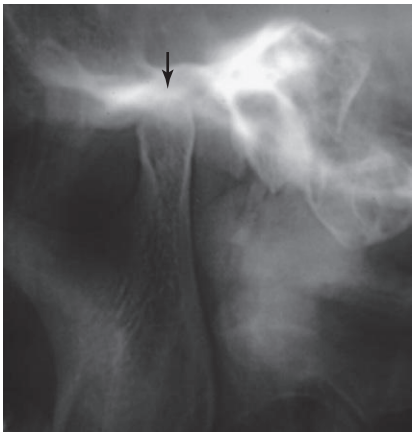

Fig. 1.25 A transcranial radiograph shows the lateral pole of the mandibular condyle *(arrow)*.

helpful in assessing third molars and impactions, screening the vertical amount of bone before making a cone-beam computed tomography (CBCT) scan for implant placement (see Chapter 13), and evaluating edentulous arches for buried root tips. However, they do not provide a detailed view sufficient for assessing bone support, root structure, caries, or periapical disease.

Special radiographs may be needed for the assessment of TMJ disorders and a wide variety of pathologic conditions ranging from bone and mineral disorders to metabolic disorders, genetic abnormalities, and soft tissue calcifications, such as carotid artery calcification.[53] For assessment of the TMJs, a transcranial exposure (Fig. 1.25), with the help of a positioning device, reveals the lateral third of the mandibular condyle and can be used to detect some structural and positional changes. However, interpretation may be difficult,[54] and more information may be obtained from other images (Fig. 1.26).[55] Cone-beam imaging is considered prerequisite to most dental implant placements. In this form of imaging, osseous contours and bone volume are visualized, which improves decision making about the size of implant fixtures that realistically can be accommodated (Fig. 1.27).

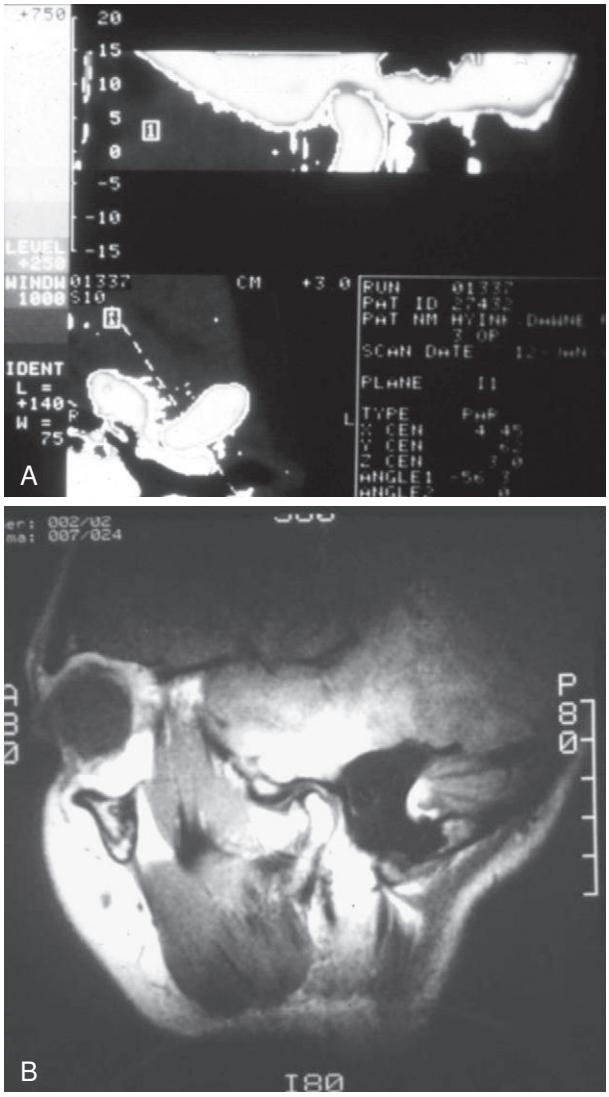

Fig. 1.26 More sophisticated techniques enable the generation of computer-assisted images of clinician-determined cross-sections. (A) A computed tomographic (CT) scan. (B) A magnetic resonance image showing the soft tissue in greater detail. (Courtesy Dr. J. Petrie.)

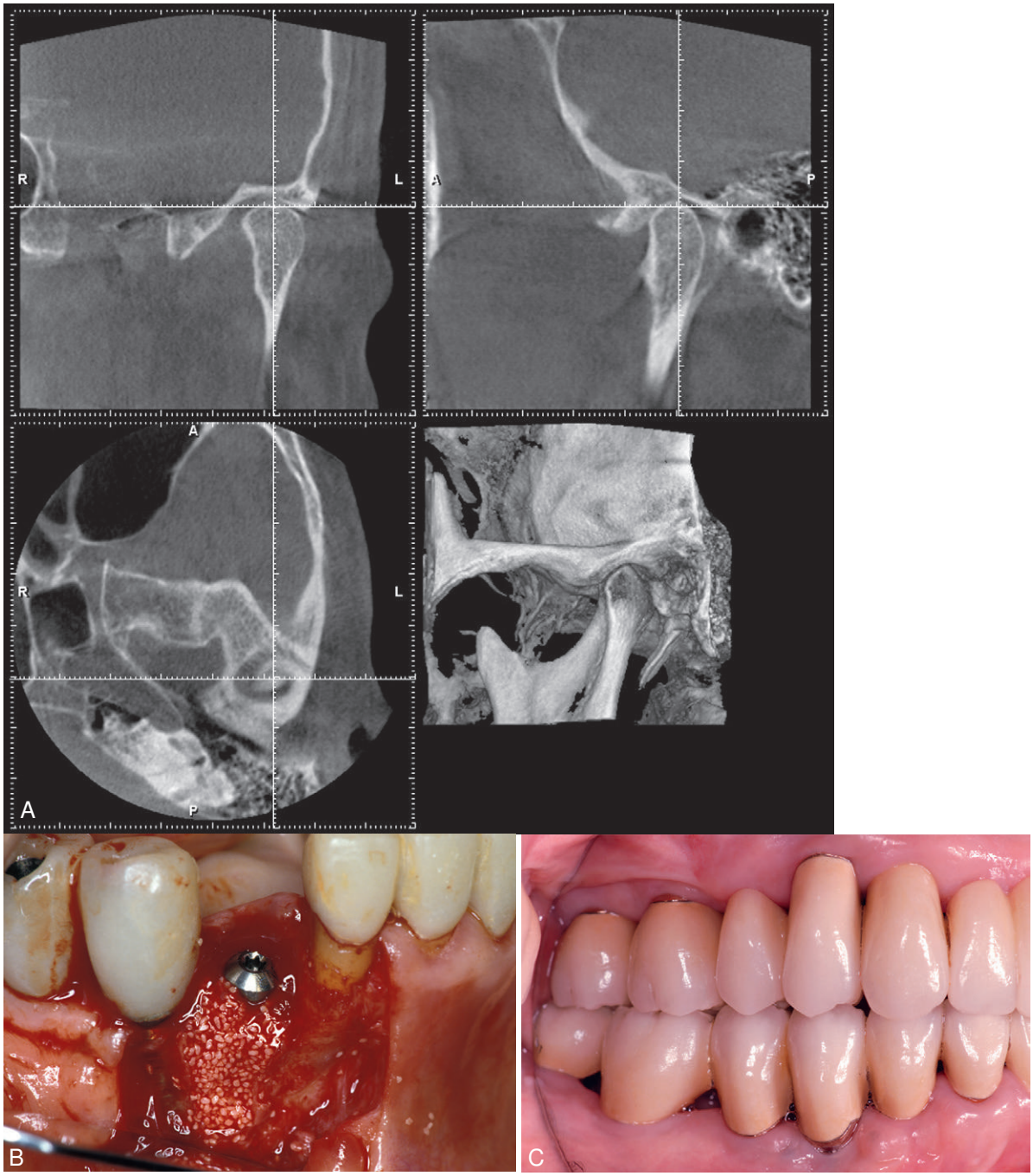

Fig. 1.27 (A) Cone beam technology is useful for definitive evaluation of pathologic conditions of the temporomandibular joint because it enables viewing of any desired cross section. (B) Ridge augmentation surgery. (C) Completed restoration.

Vitality Testing

Before any restorative treatment is begun, pulpal health must be confirmed, usually by assessing the response to thermal stimulation. However, in vitality tests, only the afferent nerve supply is assessed. Misdiagnosis can occur if the nerve supply is damaged but the blood supply is intact. Careful inspection of radiographs is therefore essential in the examination of such teeth.

DIAGNOSIS AND PROGNOSIS

Not all patients seeking fixed prosthodontic treatment have diagnostic problems. Nevertheless, diagnostic errors are possible, especially when a patient complains of pain or of symptoms of occlusal dysfunction. Treatment may be needed to eliminate obvious potential sources of the complaint, such as dental caries or a fractured tooth. A logical and systematic approach to diagnosis helps to avoid mistakes.

Differential Diagnosis

When the history and examination are complete, a differential diagnosis is made. The most likely causes of the observed conditions are identified and recorded in order of probability. A definitive diagnosis can usually be developed after such supporting evidence has been assembled.

A typical diagnosis condenses the information obtained during the clinical history taking and examination. For instance, a diagnosis could read as follows: "28-year-old man, no significant medical history; vital signs normal. Chief complaint: Mesiolingual cusp fracture on tooth #30. Teeth #1, #16, #17, #19, and #32 missing. Patient reports significant postoperative discomfort after previous molar extraction. High smile line. Caries: #6, mesial; #12, distal; #20, mesio-occlusal; and #30, mesio-occlusal–distal. Tooth #8 has received previous endodontic treatment. Generalized gingivitis in four posterior quadrants, with recession noted on teeth #23, #24, and #25; 5-mm pockets on teeth #18, #30, and #31. Radiographic evidence of periradicular pathology in tooth #30. Tooth #30 tests nonvital."

This hypothetical scenario summarizes the patient's problems, allowing subsequent prioritization as a treatment plan is developed (see Chapter 3). In this case, the patient's chief complaint probably has existed longer than the symptoms that caused the patient to seek care.

Prognosis

The prognosis is an estimation of the likely course of a disease. It can be difficult to make, but its importance to patient management and successful treatment planning must nevertheless be recognized. The prognosis of dental disorders is influenced by general factors (age of the patient, lowered resistance of the oral environment) and local factors (forces applied to a given tooth, access for oral hygiene measures). For example, a young person with periodontal disease has a more guarded prognosis than does an older person with the same disease experience. In the younger person, the disease has followed a more virulent course because of the generally less developed systemic resistance; these facts should be reflected in treatment planning.

Fixed prostheses function in a hostile setting: In the moist oral environment, the teeth are subject to constant changes in temperature and acidity and to considerable load fluctuation. A comprehensive clinical examination helps to establish the likely prognosis. All facts and observations are first considered individually and then correlated appropriately.

General Factors

The overall caries rate of the patient's dentition indicates future risk to the patient if the condition is left untreated. Important variables include the patient's understanding and comprehension of plaque-control measures, as well as the physical ability to perform those tasks. Analysis of systemic problems in the context of the patient's age and overall health provides important information. For example, the incidence of periodontal disease is higher in diabetic patients than in the general population, and special precautionary measures may be indicated in those patients before treatment begins. Such conditions also affect the overall prognosis.

Some patients are capable of exerting an extremely high occlusal force (see Fig. 7.45), whereas others are not. If muscle tone of hypertrophied elevator muscles is identified as abnormal during the extraoral examination and multiple intraoral wear facets are observed, loading of the teeth is considerably higher than in the dentition of a frail 90-year-old patient who fatigues easily when asked to close. Other important factors in determining overall prognosis are the history and success of previous dental treatments. If a patient's previous dental care has been successful over a period of many years, a better prognosis can be anticipated than when apparently properly fabricated prostheses fail or become dislodged within a few years of initial placement.

Local Factors

The observed vertical overlap of the anterior teeth has a direct effect on the load distribution in the dentition and thus can have an effect on the prognosis. Minimal vertical overlap is generally less favorable because higher load on posterior teeth results (see Chapter 4). In the presence of favorable loading, minor tooth mobility is less of a concern than in the presence of unfavorably directed or high load. Impactions adjacent to a molar that will be crowned may pose a serious threat in a younger patient, in whom additional growth can be anticipated, but may be of lesser concern in an older patient.

Individual tooth mobility, root angulation, root structure, crown-to-root ratios, and many other variables all have an effect on the overall prognosis for fixed prosthodontic devices. They are addressed later in this book (see also Chapter 3).

Prosthodontic Diagnostic Index for Partially Edentulous and Completely Dentate Patients

The American College of Prosthodontists (ACP) has developed diagnostic indices for partial edentulism[56] and for completely dentate patients[57] on the basis of diagnostic findings that are summarized here with the permission and support of the ACP. These guidelines are intended to help practitioners to determine appropriate treatments for their patients. For each index, four categories, class I to class IV, are defined; class I represents an uncomplicated clinical situation, and class IV represents a complex clinical situation. The indices are designed for use by dental professionals involved in the diagnosis and treatment of partially edentulous and completely dentate patients. Potential benefits of the system include (1) improved intraoperator consistency, (2) improved professional communication, (3) insurance reimbursement commensurate with complexity of care, (4) improved screening tool for dental school admission clinics, (5) standardized criteria for outcomes assessment and research, (6) enhanced diagnostic consistency, and (7) simplified decision to refer a patient.

Each class is differentiated by specific diagnostic criteria (ideal or minimal, moderately compromised, substantially compromised, or severely compromised) of the following (for partially edentulous patients):

1. Location and extent of the edentulous area or areas
2. Condition of the abutment teeth
3. Occlusal scheme
4. Residual ridge

For completely dentate patients, only tooth condition and occlusal scheme are evaluated.

Location and Extent of the Edentulous Areas

In the *ideal or minimally compromised edentulous area*, the edentulous span is confined to a single arch, and one of the following conditions is present:

- Any anterior maxillary span that does not exceed two missing incisors
- Any anterior mandibular span that does not exceed four missing incisors
- Any posterior maxillary or mandibular span that does not exceed two premolars or one premolar and one molar

In the *moderately compromised edentulous area*, the edentulous span is in both arches, and one of the following conditions exists:

- The span includes any anterior maxillary span that does not exceed two missing incisors.
- The span includes any anterior mandibular span that does not exceed four missing incisors.
- The span includes any posterior maxillary or mandibular span that does not exceed two premolars or one premolar and one molar.
- The maxillary or mandibular canine tooth is missing.

The substantially compromised edentulous area includes the following conditions:

- Any posterior maxillary or mandibular span that is greater than three missing teeth or two molars
- Any edentulous span, including anterior and posterior areas of three or more missing teeth

The *severely compromised edentulous area* includes the following condition:

- Any edentulous area or combination of edentulous areas whose care requires a high level of patient compliance

Condition of the Abutment Teeth (Tooth Condition for Completely Dentate Patients)

In cases of ideal or minimally compromised abutment teeth,

- No preprosthetic therapy is indicated.

In cases of moderately compromised abutment teeth,

- Tooth structure is insufficient to retain or support intracoronal restorations, in one or two sextants.
- Localized adjunctive therapy (i.e., periodontal, endodontic, or orthodontic procedures, in one or two sextants) is required for abutments.

In cases of substantially compromised abutment teeth,

- Tooth structure is insufficient to retain or support intracoronal or extracoronal restorations, in four or more sextants.
- Extensive adjunctive therapy (i.e., periodontal, endodontic or orthodontic procedures, in four or more sextants) is required for abutments.

In cases of severely compromised abutment teeth,

- Abutments have a guarded prognosis.

Occlusal Scheme

Ideal or minimally compromised occlusal schemes are characterized by the following conditions:

- No preprosthetic therapy required
- Class I molar and jaw relationships

Moderately compromised occlusal schemes are characterized by the following conditions:

- Necessity for localized adjunctive therapy (e.g., enameloplasty on premature occlusal contacts)
- Class I molar and jaw relationships

Substantially compromised occlusal schemes are characterized by the following conditions:

- Necessity for reestablishment of entire occlusal scheme but without any change in the occlusal vertical dimension
- Class II molar and jaw relationships

Severely compromised occlusal schemes are characterized by the following conditions:

- Necessity for reestablishment of entire occlusal scheme, with changes in the occlusal vertical dimension
- Class II, division 2, and class III molar and jaw relationships

Residual Ridge

The Classification System for Complete Edentulism[58] is used to categorize any edentulous span present in a partially edentulous patient. The residual ridge can be classified by the method devised by Seibert (see Chapter 3).

Classification System

The four criteria and their subclassifications are organized into an overall classification system for partial edentulism; the two criteria provide the system for completely edentulous patients.

Class I

This class (Figs. 1.28 and 1.29) is characterized by ideal or minimal compromise in the location and extent of an edentulous area (which is confined to a single arch), abutment conditions, occlusal characteristics, and residual ridge conditions. All four of the diagnostic criteria are favorable.

1. The location and extent of the edentulous area are ideal or minimally compromised:
   - The edentulous area is confined to a single arch.
   - The edentulous area does not compromise the physiologic support of the abutments.
   - The edentulous area may include any anterior maxillary span that does not exceed two incisors, any anterior mandibular span that does not exceed four missing incisors, or any posterior span that does not exceed two premolars or one premolar and one molar.
2. The abutment condition is ideal or minimally compromised, with no need for preprosthetic therapy.
3. The occlusion is ideal or minimally compromised, with no need for preprosthetic therapy; maxillomandibular relationship consists of class I molar and jaw relationships.
4. Residual ridge structure conforms to the class I complete edentulism description.

Class II

This class (Figs. 1.30 and 1.31) is characterized by moderately compromised location and extent of edentulous areas in both

Fig. 1.28 Class I. This patient is categorized as class I because of an ideal or minimally compromised edentulous area, abutment condition, and occlusion. There is a single edentulous area in one sextant. The residual ridge is considered type A. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Frontal view, protrusive relationship. (G) Right lateral view, right working movement. (H) Left lateral view, left working movement. (I) Full-mouth radiographic series. (From McGarry TJ, Nimmo A, Skiba JF, et al: Classification system for partial edentulism, *J Prosthodont*. 2002;11:181.)

arches, abutment conditions that necessitate localized adjunctive therapy, occlusal characteristics that necessitate localized adjunctive therapy, and residual ridge conditions.

1. The location and extent of the edentulous area are moderately compromised:
   - Edentulous areas may exist in one or both arches.
   - The edentulous areas do not compromise the physiologic support of the abutments.
   - Edentulous areas may include any anterior maxillary span that does not exceed two incisors, any anterior mandibular span that does not exceed four incisors, any posterior span (maxillary or mandibular) that does not exceed two premolars, or one premolar and one molar or any missing canine (maxillary or mandibular).
2. Condition of the abutments is moderately compromised:
   - Abutments in one or two sextants have insufficient tooth structure to retain or support intracoronal or extracoronal restorations.
   - Abutments in one or two sextants necessitate localized adjunctive therapy.

Fig. 1.29 Class I. This patient is categorized as class I because an ideal or minimally compromising tooth condition and occlusal scheme are exhibited. A single large amalgam core restoration requires a complete coverage restoration in one sextant. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Panoramic radiograph. (From McGarry TJ, Nimmo A, Skiba JF, et al: Classification system for the completely dentate patient, *J Prosthodont*. 2004;13:73.)

3. Occlusion is moderately compromised:
   - Occlusal correction necessitates localized adjunctive therapy.
   - Maxillomandibular relationship is characterized as class I molar and jaw relationships.
4. Residual ridge structure conforms to the class II description of complete edentulism.

Class III

This class (Figs. 1.32 and 1.33) is characterized by substantially compromised location and extent of edentulous areas in both arches, abutment condition that necessitates substantial localized adjunctive therapy, occlusal characteristics that necessitate reestablishment of the entire occlusion without a change in the occlusal vertical dimension, and residual ridge conditions.

1. The location and extent of the edentulous areas are substantially compromised:
   - Edentulous areas may be present in one or both arches.
   - Edentulous areas compromise the physiologic support of the abutments.
   - Edentulous areas may include any posterior maxillary or mandibular edentulous area greater than three teeth or two molars or anterior and posterior edentulous areas of three or more teeth.
2. The condition of the abutments is moderately compromised:
   - Abutments in three sextants have insufficient tooth structure to retain or support intracoronal or extracoronal restorations.
   - Abutments in three sextants necessitate more substantial localized adjunctive therapy (i.e., periodontal, endodontic, or orthodontic procedures).
   - Abutments have a fair prognosis.
3. Occlusion is substantially compromised:
   - The entire occlusal scheme must be reestablished without an accompanying change in the occlusal vertical dimension.
   - Maxillomandibular relationship is characterized as class II molar and jaw relationships.
4. Residual ridge structure conforms to the class III complete edentulism description.

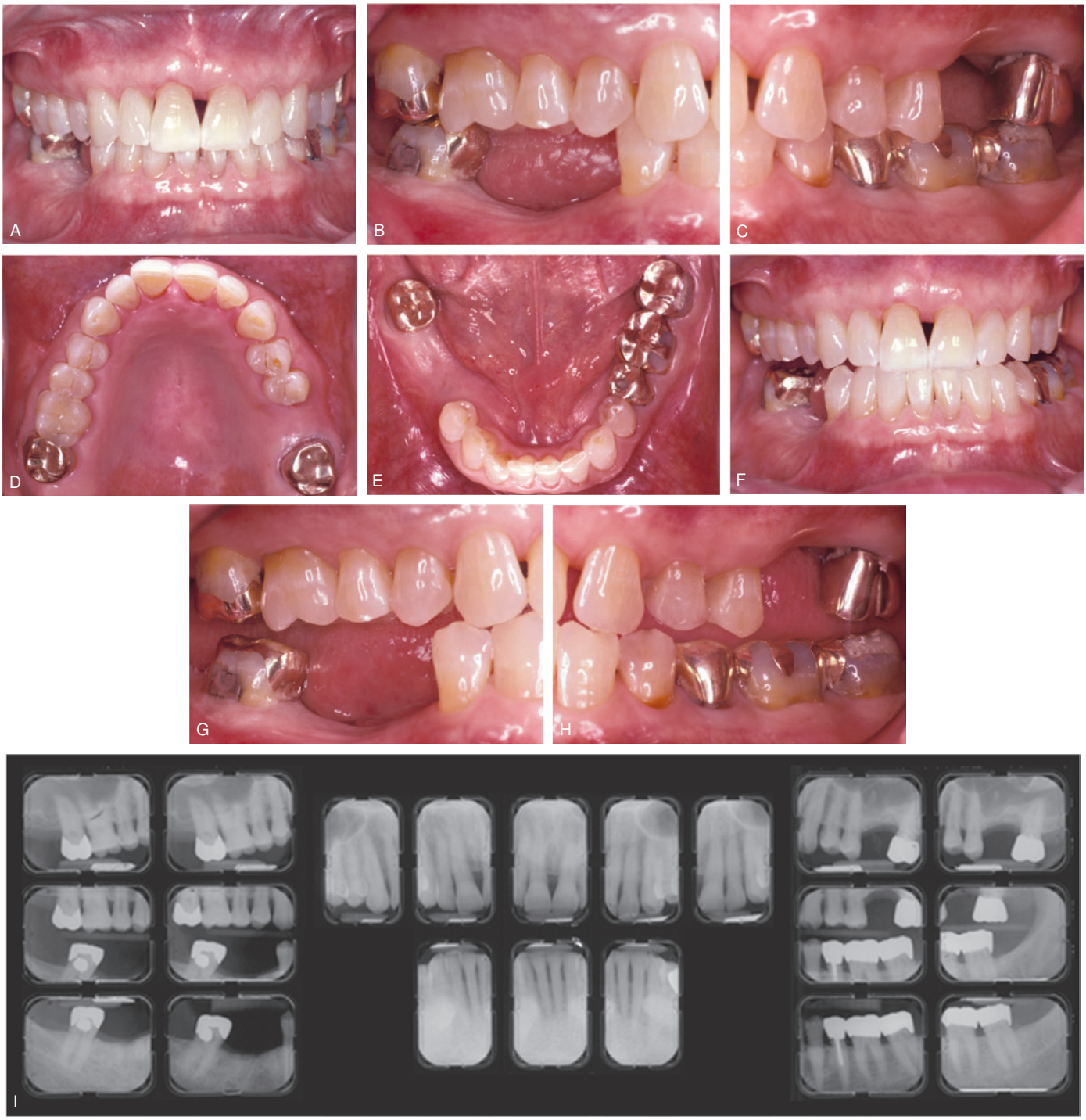

Fig. 1.30 Class II. This patient is categorized as class II because edentulous areas are present in two sextants in different arches. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Frontal view, protrusive relationship. (G) Right lateral view, right working movement. (H) Left lateral view, left working movement. (I) Full-mouth radiographic series. (From McGarry TJ, Nimmo A, Skiba JF, et al. Classification system for partial edentulism. *J Prosthodont*. 2002;11:181.)

Fig. 1.31 Class II. This patient is categorized as class II because one sextant exhibits three defective restorations with an esthetic component. Additional variables of gingival architecture and individual tooth proportions increase the complexity of diagnosis. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Panoramic radiograph. (From McGarry TJ, Nimmo A, Skiba JF, et al. Classification system for the completely dentate patient. *J Prosthodont*, 2004;13:73.)

Fig. 1.32 Class III. This patient is categorized as class III because the edentulous areas are located in both arches and there are multiple such locations within each arch. The abutment condition is substantially compromised as a result of the need for extracoronal restorations. There are teeth that are extruded and malpositioned. The occlusion is substantially compromised because reestablishment of the occlusal scheme is required without a change in the occlusal vertical dimension. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Frontal view, protrusive relationship. (G) Right lateral view, right working movement. (H) Left lateral view, left working movement. (I) Full-mouth radiographic series. (From McGarry TJ, Nimmo A, Skiba JF, et al. Classification system for partial edentulism, *J Prosthodont*. 2002;11:181.)

Fig. 1.33 Class III. This patient is categorized as class III because large defective amalgam and composite resin restorations are present in four sextants. The remaining tooth structure is substantially compromised in most posterior teeth. The occlusion is substantially compromised, which necessitates reestablishment of the occlusal scheme without a change in the occlusal vertical dimension. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Panoramic radiograph. (From McGarry TJ, Nimmo A, Skiba JF, et al. Classification system for the completely dentate patient, *J Prosthodont*. 2004;13:73.)

Class IV

This class (Figs. 1.34 and 1.35) is characterized by severely compromised location and extent of edentulous areas with guarded prognosis, abutment conditions that necessitate extensive therapy, occlusion characteristics that necessitate reestablishment of the occlusion with a change in the occlusal vertical dimension, and residual ridge conditions.

1. The location and extent of the edentulous areas result in severe occlusal compromise:
   - Edentulous areas may be extensive and may be present in both arches.
   - Edentulous areas compromise the physiologic support of the abutment teeth, and so the prognosis is guarded.
   - Edentulous areas include acquired or congenital maxillofacial defects.
   - At least one edentulous area has a guarded prognosis.
2. Abutments are severely compromised:
   - Abutments in four or more sextants have insufficient tooth structure to retain or support intracoronal or extracoronal restorations.
   - Abutment conditions in four or more sextants necessitate extensive localized adjunctive therapy.
   - Abutments have a guarded prognosis.
3. Occlusion is severely compromised:
   - Reestablishment of the entire occlusal scheme, including changes in the occlusal vertical dimension, is necessary.
   - Maxillomandibular relationship is characterized as class II, division 2, or class III molar and jaw relationships.
4. Residual ridge structure conforms to the class IV complete edentulism description.

Other characteristics include severe manifestations of local or systemic disease, including sequelae from oncologic treatment, maxillomandibular dyskinesia or ataxia, and refractoriness (a patient's presenting with chronic complaints after appropriate therapy).

Guidelines for the Use of Prosthodontic Diagnostic Index Classification System for Partial Edentulism and Complete Dentition

The analysis of diagnostic factors is facilitated with the use of a worksheet (Fig. 1.36 and Table 1.1). Each criterion is evaluated, and a checkmark is placed in the appropriate box. In instances in which a patient's diagnostic criteria overlap two or more classes, the more complex class is the selected diagnosis.

Fig. 1.34 Class IV. This patient is categorized as class IV because edentulous areas are found in both arches, and the physiologic abutment support is compromised. Abutment condition is severely compromised as a result of advanced attrition and failing restorations, which necessitate extracoronal restorations and adjunctive therapy. The occlusion is severely compromised, which necessitates reestablishment of occlusal vertical dimension and proper occlusal scheme. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Frontal view, protrusive relationship. (G) Right lateral view, right working movement. (H) Left lateral view, left working movement. (I) Full-mouth radiographic series. (From McGarry TJ, Nimmo A, Skiba JF, et al. Classification system for partial edentulism, *J Prosthodont.* 2002;11:181.)

Fig. 1.35 Class IV. This patient is categorized as class IV because advanced attrition of the occlusal surfaces is present in more than three sextants. The occlusion is severely compromised, which necessitates reestablishment of occlusal vertical dimension and a proper occlusal scheme. (A) Frontal view, maximum intercuspation. (B) Right lateral view, maximum intercuspation. (C) Left lateral view, maximum intercuspation. (D) Occlusal view, maxillary arch. (E) Occlusal view, mandibular arch. (F) Panoramic radiograph. (From McGarry TJ, Nimmo A, Skiba JF, et al. Classification system for the completely dentate patient, *J Prosthodont*. 2004;13:73.)

The following additional guidelines should be followed to ensure consistent application of the classification system:

1. Consideration of future treatment procedures must not influence the choice of diagnostic level.
2. Initial preprosthetic treatment or adjunctive therapy can change the initial classification level. Classification may need to be reassessed after existing prostheses are removed.
3. Esthetic concerns or challenges raise the classification by one level in cases of class I and class II dentition.
4. The presence of symptoms of temporomandibular disorder raises the classification by one or more levels in patients with class I and class II dentition.
5. In a patient presenting with an edentulous maxilla opposing a partially edentulous mandible, each arch is diagnosed according to the appropriate classification system; that is, the maxilla is classified according to the complete edentulism classification system, and the mandible is classified according to the partial edentulism classification system. The sole exception to this rule is the case of an edentulous mandible opposed by a partially edentulous or dentate maxilla. This clinical situation entails significant complexity and potential long-term morbidity and, as such, should be categorized as class IV in either system.
6. Periodontal health is intimately related to the diagnosis and prognosis for partially edentulous patients. For the purpose of this system, it is assumed that patients receive therapy to achieve and maintain periodontal health so that appropriate prosthodontic care can be accomplished.

Description	Class I	Class II	Class III	Class IV
Location and Extent of Edentulous Areas				
Ideal or minimally compromised: single arch				
Moderately compromised: both arches				
Substantially compromised: more than three teeth				
Severely compromised: guarded prognosis				
Congenital or acquired maxillofacial defect				
Abutment Condition				
Ideal or minimally compromised				
Moderately compromised: one to two sextants				
Substantially compromised: three sextants				
Severely compromised: four or more sextants				
Occlusion				
Ideal or minimally compromised				
Moderately compromised: local adjunctive treatment				
Substantially compromised: occlusal scheme				
Severely compromised: change in occlusal vertical dimension				
Residual Ridge				
Class I edentulous				
Class II edentulous				
Class III edentulous				
Class IV edentulous				
Conditions Creating a Guarded Prognosis				
Severe oral manifestations of systemic disease				
Maxillomandibular dyskinesia and/or ataxia				
Refractory condition				

Fig. 1.36 Worksheet used to determine prosthodontic diagnostic index classification. Note: Individual diagnostic criteria are evaluated, and the appropriate box is checked. The most advanced finding determines the final classification. Guidelines for use of the worksheet: (1) Possession of any single criterion of a more complex class places the patient into the more complex class. (2) Consideration of future treatment procedures must not influence the diagnostic level. (3) Initial preprosthetic treatment and/or adjunctive therapy can change the initial classification level. (4) If there is an esthetic concern/challenge, the classification is increased in complexity by one level in class I and II patients. (5) In the presence of symptoms of temporomandibular disorder, the classification is increased in complexity by one or more levels in class I and II patients. (6) In the situation in which the patient presents with an edentulous mandible opposing a partially edentulous or dentate maxilla, the patient is categorized as class IV.

TABLE 1.1 Worksheet Used to Determine Prosthodontic Diagnostic Index Classification of Completely Dentate Patients

Description	Class I	Class II	Class III	Class IV
Teeth Condition				
Ideal or minimally compromised: three or fewer teeth in one sextant	X			
Moderately compromised: one or more teeth in one to two sextants		X		
Substantially compromised: one or more teeth in three to five sextants			X	
Severely compromised: four or more teeth, all sextants				X
Occlusal Scheme				
Ideal or minimally compromised	X			
Moderately compromised: anterior guidance intact		X		
Substantially compromised: extensive rest/same OVD			X	
Severely compromised: extensive rest/new OVD				X
Conditions Creating a Guarded Prognosis				
Severe oral manifestations of systemic disease				X
Maxillomandibular dyskinesia or ataxia				X
Refractory condition				X

Note: Individual diagnostic criteria are evaluated, and the appropriate box is checked. The most advanced finding determines the final classification.

Guidelines for use of this worksheet:

1. Consideration of future treatment procedures must not influence the diagnostic level.
2. Initial preprosthetic treatment or adjunctive therapy can change the initial classification level.
3. If there is an esthetic concern/challenge, the classification is increased in complexity by one or more levels.
4. In the presence of temporomandibular joint symptoms, the classification is increased in complexity by one or more levels.
5. It is assumed that the patient will receive therapy designed to achieve and maintain optimal periodontal health.
6. Situations that fail to conform to the definition of completely dentate should be classified according to the classification system for partial edentulism.

OVD, Occlusal vertical dimension.

The classification system for partial edentulism is based on the most objective criteria available to facilitate uniform use of the system. Such standardization may help to improve communications among dental professionals and third parties. This classification system serves to identify patients most likely to require treatment by a specialist or by a practitioner with additional training and experience in advanced techniques. This system should also be valuable to research protocols as different treatment procedures are evaluated. With the increasing complexity of treatment, this partial edentulism classification system, coupled with the complete edentulism classification system, helps dental school faculty to assess entering patients for the most appropriate patient assignment for better care. On the basis of use and observations by practitioners, educators, and researchers, this system is modified as needed.

SUMMARY

A comprehensive history and a thorough clinical examination provide sufficient data for the practitioner to formulate a successful treatment plan. If they are too hastily accomplished, details may be missed, which can cause significant problems during treatment, when it may be difficult or impossible to make corrections. In addition, the overall outcome and prognosis may be adversely affected. In particular, it is crucial to develop a thorough understanding of each patient's special concerns relating to previous care and his or her expectations about future treatment. Many problems encountered during fixed prosthodontic treatment are directly traceable to factors overlooked during the initial examination and data collection. A diagnosis is a summation of the observed problems and their underlying causes. The patient's overall prognosis is influenced by general and local factors.

STUDY QUESTIONS

1. Discuss the importance of the chief complaint and its management during examination and presentation of the treatment plan.
2. What is the classification of conditions observed as part of the medical history?
3. Describe the various areas included in the documentation of a comprehensive dental history.
4. What systemic conditions may cause oral manifestations that can affect a plan for fixed prosthodontic treatment?

5. What is included in a comprehensively conducted extraoral examination? Specify all structures included in palpation.
6. Discuss three critical observations that are part of a comprehensive periodontal examination. Why are they important in the evaluation for fixed prosthodontic treatment?
7. What would be recorded as part of an intraoral charting?
8. Discuss the various types of radiographs available for diagnostic purposes. What are the advantages and limitations of each technique?
9. Give examples of general and local factors that may influence the patient's prognosis.

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2

Diagnostic Procedures

At data collections appointments, the care provider is a scientist. As the scientist, the main goal is to collect all information relevant to the needs of the patient so that individualized treatment plan options can be offered. This chapter provides a resource of information that can be considered for collection to address specific patient needs. Instructions and armamentarium for clinical photography are given, and the analysis of the data within the clinical photographs and correlation with dentofacial analysis and diagnostic casts is discussed. Methods to record centric relation (CR) and its relevance in digital and traditional fixed prosthodontics are detailed. Excellent patient communication is based on the collection, processing, and presentation of the correct data relevant to the needs of the individual patient. Digital smile designs and diagnostic templates are helpful aids in patient communication so that patients better understand the dentists' scientific endeavors.

CLINICAL PHOTOGRAPHY

Dental photography has many uses in fixed prosthodontics. First, photographs record the patient's initial presentation to aid in the diagnostic process, communicate needs to other specialists, and to help communicate to the patient the clinical findings and the objectives of their treatment. Second, photographs are used throughout treatment to record critical steps, to track progression of healing for periodic reevaluations, and to determine if treatment is progressing without complications or if adjustments are warranted in the treatment plan. Third, photographs are used to communicate with laboratory technicians and master ceramists to facilitate one's vision on color, shade, contours, proportions, and positions of the future restorations before, during, and even after their fabrication. Fourth, dental photography is valuable in showing patients how their new restorations look before they give consent to cementation. It is of great value to leave the dental operatory and sit down with patients to critically review their own images to confirm their satisfaction with the esthetic appearance that has been achieved. Such an extra step has proven to be one key to success. Fifth, photographs are important to record the postcementation of the definitive restorations once the treatment plan is finalized. Not only does such document the completed treatment, but more importantly it is useful at later reevaluation appointment throughout the continuation of the patient's dental maintenance. Last, dental photography permits thorough documentation of treatment rendered, which may prove helpful if a legal situation evolves.

Armamentarium

- SLR digital camera
- True macro lens; the focal length of the lens will depend upon the image size of the camera. Typically, it is a 100-mm or a 105-mm macro lens.
- Ring flash or twin flash
- Camera case
- Camera neck strap
- 2 yards of black velvet
- Four sets of transparent plastic cheek retractors
- Dental mirrors
  - Large occlusal
  - Medium occlusal
  - Small occlusal
  - Large buccal
  - Medium buccal
  - Small buccal
- Intraoral contraster (black paddle)
- Mixing bowl
- Warm water
- 4 × 4 cotton gauze

A high-quality digital camera is one of the most important investments one can make for a dental practice. However, cameras used in a clinical setting are at high risk of getting dropped and damaged. To minimize the high risk of damage, the photographer should always follow two simple rules.

Rule #1: When the camera is not in use, store it in a professional camera case. A case will protect the camera from a blunt impact like a fall. In addition, a camera case will protect the camera from dust. Over time if a camera is left out in the elements, dust and debris will migrate into the camera and lens and contaminate the camera's digital sensor. When debris migrates into the camera, the quality of pictures will be negatively affected. Many times, debris will result in unwanted black spots in the pictures.

Rule #2: When in use, it is highly recommended for the photographer to always wear the camera's neck strap. A neck strap frees up the photographer's hands for when cheek retractors and mirrors are being inserted into the patient's mouth. With the camera hanging around the photographer's neck, fewer hand transfers are required of the camera between the

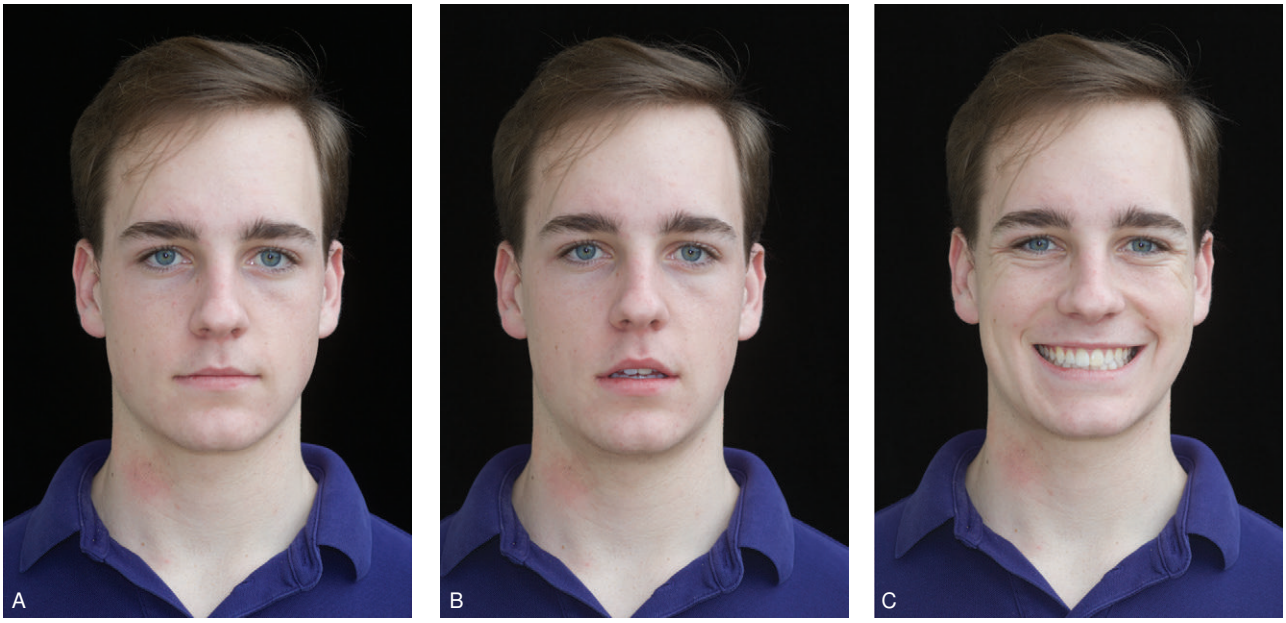

Fig. 2.1 Frontal portrait. (A) Lips together. (B) Repose. (C) Smile.

photographer and assistant. It takes only one drop to render a digital camera inoperable.

Extraoral photographs should be made before the intraoral photographs and diagnostic impressions. The logic is simple: photographs of blushed faces resulting from pulling on the lips and cheeks with retractors and mirrors are of lesser value. Similarly, one would not want images that show smeared impression material on the face or pieces of impression material between the teeth. As a result, the recommended sequence is first extraoral photographs, followed by intraoral photographs, and then diagnostic impressions and occlusal records.

Extraoral Photographs

The concept in photography for fixed prosthodontics is to start with a global view and then progress down to a microscopic view. Following this logic, a frontal view of the full face is the starting point. Mount on a wall the 2 yards of black velvet purchased at a fabric store. The black velvet will eliminate shadows cast on the wall from the camera's flash. Position the patient in a swivel chair 2 feet away from the wall in front of the black background. Frame the picture to include the top of the patient's head down to the collar bone. Both right and left ears need to be in the frame. If long hair is covering the ears, have the patient bring the hair behind his or her ears. Exposure of the ears helps to correlate lateral cephalometric analysis if one is needed (see Fig. 2.2D). The working distance (i.e., the distance between the patient and the front of the camera lens) is approximately 150 to 200 cm (60 to 80 inches), but there is variability between camera brands. The aperture should be set between f/5.6 and f/8. The shutter speed may be set automatically with some brands of cameras. With a Canon camera, the shutter speed is set to $\frac{1}{125}$ second. The focal length will vary with the brand of macro lens, but typically it is approximately 6 feet or 2 m. Focus on the patient's eyes. Make a few pictures with the patient's lips together and the teeth in maximal intercuspation. Once you have confirmed the camera settings, have the patient wet and slightly separate the lips. Instruct the patient with the lips separated to completely relax all facial muscles. The relaxed or reposed facial expression is the starting point for all facial expressions. After the repose photograph has been made, instruct the patient to smile (Fig. 2.1).

Once the three ideal frontal photographs have been obtained, have the patient turn 90 degrees in the swivel chair for three profile photographs: lips together with teeth in maximum intercuspation (MI), repose, and smile (Fig. 2.2). Make sure that long hair is still brushed behind the ears.

With the completion of the profile view, have the patient turn back to face the photographer. The photographer will now shorten the working distance to 25 to 40 cm (10 to 15 inches) to photograph the lips in repose and smiling. To do this, dial the aperture down to f/32 and set the shutter speed at $\frac{1}{125}$ of a second. The lens position will range from 0.45 to 0.50 m (dependent on the manufacturer) because macro lenses will have a small variation dependent upon their focal length. One helpful hint for the smile line is the effect of the angle of the camera to the occlusal plane. A camera positioned a few degrees above the occlusal plane gives the appearance of a curvature in the maxillary incisal edge that follows a similar curve of the lower lip.[1] During the data collection phase, this optical illusion is generally not wanted. To calibrate photographs, the camera is parallel to the occlusal plane. Once the repose and smile frontal photographs are captured, the subject can turn in the swivel chair face the photographer and produce the close-up photographs of repose and smile with the same camera settings (Fig. 2.3).

Intraoral Photographs

For best visual acuity, composition, and exposure, maximal retraction of the lips and buccal mucosa are essential when taking intraoral photographs. Transparent plastic cheek retractors are preferred over metal ones because they are less distracting if captured in the picture. Adult-sized clear plastic cheek

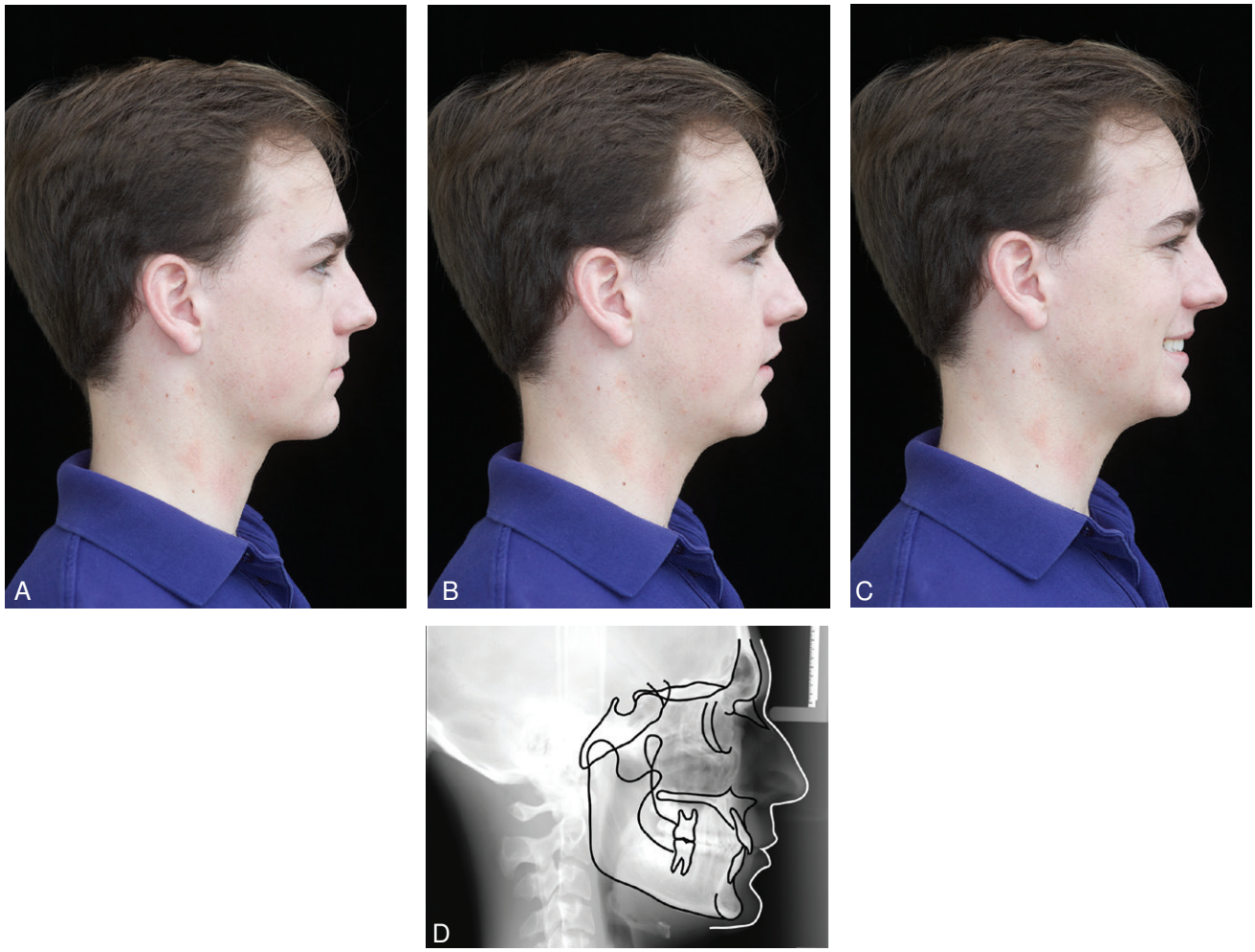

Fig. 2.2 Profile portrait. (A) Lips together. (B) Repose. (C) Smile. (D) An analysis can be done on a lateral cephalogram to evaluate facial proportions, incisor positions, and maxilla and mandible positions.

retractors can be modified with conventional dental slow speed separating discs and denture acrylic polishing equipment. Removal of three quarters of an inch from the apex of each wing of the retractors produces a medium-size retractor. Likewise, the removal of 1.0 inch from all retractor wings cre ates an essential size for the small mouth. Sectioning away most of one wing from a set of plastic retractors makes for easy occlu sal retraction. However, before modifying the retractors, it is highly recommended to mark the location of the intended cuts with a marker. Modifications differ, respectively, for a right and left retractor (Fig. 2.4).

First (or front) surface mirrors (FSMs) produce fine image resolution without ghosting and double imaging as created with second (back) surface mirrors. Available scratch-resistant coatings deliver a durable mirror that, with a little care, will provide a long period of service. Dental mirrors and plastic cheek retractors are autoclave safe. After intraoral use, never place the mirrors in an ultrasonic cleaner. Instead, wash with soap and water and then individually wrap the mirrors in 4 × 4 cotton gauze and bag to be autoclaved.

Dental patients should be seated in the dental chair for all of the following intraoral photographs. The dental chair can be reclined so the patient is supine while the photographer stands next to him or her.

The retracted frontal view picture should be framed to include the maxillary and mandibular teeth in occlusion. No mirror is used. Both dental arches, including the buccal surfaces of all posterior teeth, should fill the frame. The occlusal plane and the dental midline should form an imaginary cross in the center of the frame with the same working distance as the close-up photographs of the lips, approximately 25 to 40 cm (10 to 15 inches). With some practice, many patients can hold their own retractors. The lips need to be retracted laterally and anteriorly to expose the buccal surfaces of the posterior teeth and to capture maximal light from the camera's flash. The aperture should be down to f/32 or as small as the camera will allow. One may let the camera automatically set the shutter speed, or, if a manual setting is preferred, $\frac{1}{125}$ of a second is recommended. The lens position will range from 0.45 to 0.50, depending on the brand of macro lens. Once the camera is set and the patient is in position, focus by bodily moving the camera back and forward to focus on the canines and first premolars. A helpful hint is when the subject is practicing with the retractors, use a slow speed saliva ejector to remove the excess saliva between the teeth and

Fig. 2.3 Extraoral frontal views. (A) Repose. (B) Smile. (C) Profile in repose. (D) Smile in profile.

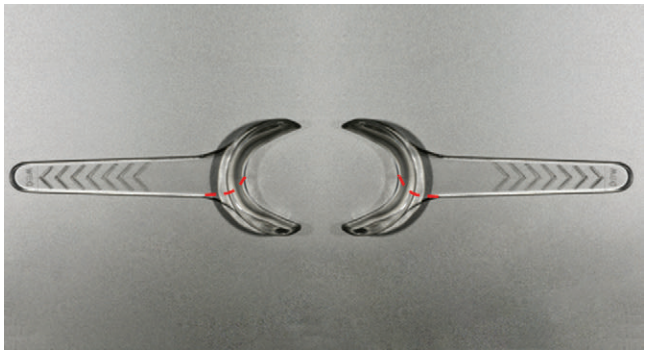

Fig. 2.4 Planning the modification of cheek retractors to make space for an occlusal mirror.

Fig. 2.5 Example of framing the photograph before looking through the camera for the frontal retracted view.

cheeks. When copious amounts of saliva persist, place cotton rolls in the lingual border of the mandible, under the tongue. However, if many teeth are missing, the cotton roll will be visible and negatively affect the photographs. An additional hint is to frame the picture with your eyes before bringing the camera up and viewing through the viewfinder. It is much more difficult to orient oneself and frame the ideal photograph when the first attempt is through the camera's viewfinder (Fig. 2.5).

The right and left buccal view pictures use the same aperture, shutter speed, and working distance as the retracted frontal view picture. Keeping the same working distance will calibrate tooth size across all intraoral photographs. With the teeth in occlusion, the canines and most posterior teeth all should be within the frame. Centered in the frame, the occlusal plane should divide the photograph in half. No direct imaging of the teeth should occur. To achieve an ideal buccal view, place the buccal mirror in hot water. A warm mirror will not fog when used intraorally. Have the patient insert both retractors while the photographer is drying and removing all smudge marks from the warm mirror with sterile 4 × 4 cotton. With the retractors deflecting the lips and cheeks and the patient's jaws

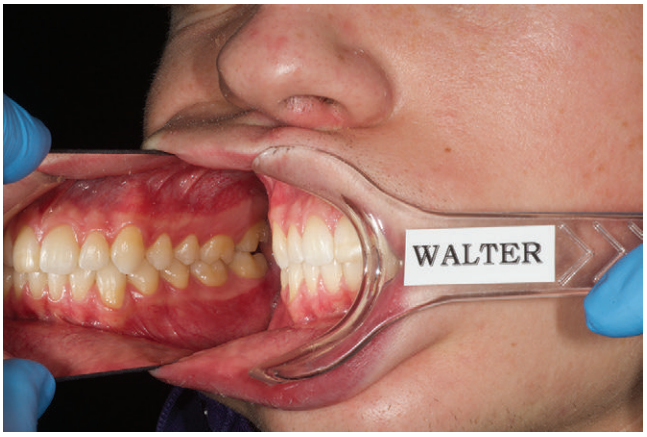

Fig. 2.6 Example of how to frame the photograph before framing through the viewfinder for the retracted buccal view.

Fig. 2.7 Retracted maxillary occlusal view. Note the modified cheek retractors to accommodate space for the large occlusal mirror.

separated, place the buccal mirror between the cheek and teeth. Once in place, remove the retractor that is on the same side as the buccal mirror and have the patient close into maximal intercuspation. Without touching the last molar or the surrounding posterior soft tissues with the mirrors end, rotate the mirror to a 45-degree angle from the buccal surfaces of the teeth. The buccal mirror can now be used as a substitute for a cheek retractor and is pressed against the corner of the mouth. The mirror is made of double-strength glass so it will not break during intraoral use, but for patient comfort, care is needed not to apply too much pressure. To achieve the 45-degree mirror position, the patient needs to bring the contralateral cheek retractor toward their midline to allow the lips to move toward the side with the mirror. Before the photographer sights through the viewfinder, they should frame the picture first with a naked eye (Fig. 2.6). It may be quite awkward to attempt to frame the picture through the viewfinder first while reflecting the image off of a mirror. In addition, framing the picture first without the camera will decrease patient discomfort and reduce the risk that the delicate soft tissues are pinched with the edge of the mirror. Once the picture is framed, the photographer brings the camera up and views the frame through the viewfinder while focusing on the premolar area. After completion of one buccal view picture, the steps are repeated to capture the contralateral buccal view with the positions of the retractor and mirror reversed.

The maxillary occlusal view photograph should include the entire maxillary arch from the central incisor to the most posterior tooth or tuberosity. The labial surfaces of the central incisors need to be parallel with the top of the frame and the midline centered in the frame. Many times, the midpalatal suture and palatal rugae are handy aids in centering the picture (Fig. 2.7). While the aperture and shutter speed are the same as the frontal and buccal view settings, the working distance may increase to 0.50 to 0.60 m if needed to simplify the framing of the occlusal photograph. During the postprocessing stage, the picture can be cropped to eliminate the unwanted parts. To capture the maxillary occlusal view, keep the patient in the supine position in the dental chair. Use the modified cheek retractors with the one wing completely removed, and have the patient gently deflect the upper lip anteriorly and superiorly. Dry the occlusal surfaces of the teeth with compressed air. Place the dry warm occlusal mirror on top of the tongue in the area where the retractor wings were removed. The largest side of the occlusal mirror that fits in the patient's mouth should be selected. A large mirror will aid in retracting the buccal mucosa near the last molar teeth. The photographer takes a position behind the supine patient and shoots over the patient's head into the mirror while the patient retracts and opens as wide as possible. To keep fingers out of the frame, the mirror is grasped from underneath and held at a 45-degree angle to the occlusal arch without contacting the teeth or pinching soft tissues in the posterior. Likewise, the camera is aimed at a 45-degree angle to the mirror.

The mandibular occlusal view includes the complete mandibular arch, from central incisor to last molar. Ideally, the dorsal surface of the tongue is not in the photograph. The labial surface of mandibular central incisor parallels the bottom of the frame and the patient's midline is centered. As with the maxillary occlusal view photograph, the mandibular occlusal working length will range from 0.45 to 0.60 m, and the patient is left in the supine position in the dental chair. Depending on the brand of camera, the aperture and shutter speed are left the same as the previous intraoral views, f/32 and $\frac{1}{125}$ second. While the largest occlusal mirror that will fit in the patient's mouth is warming in the water, have the subject switch the retractors with the missing wings in their hands to retract the lower lip. Dry and polish clean the mirror with sterile 4 × 4 cotton gauze, instruct the patient to lift up their tongue, and use the mirror to retract the tongue posteriorly, out of the frame. The patient's tongue is retracted out of the frame because the dental arch is the subject of the photograph and a tongue would be distracting if it is not intended to be the subject of the image. With the patient's tongue retracted out of the frame, the lingual frenum of the tongue is a helpful aid for centering the photograph. Tilt the mirror to a 45-degree angle to the mandibular occlusal plane without contacting the mandibular arch. Position the camera approximately 45-degree angle to the warm, clean mirror. Ask the patient to open wide, and make sure the retractors are keeping the lower lip away from the mandibular anterior teeth (Fig. 2.8). Once again, after framing with the naked eye,

Fig. 2.8 Example of how the occlusal view would appear before it is framed through the camera's viewfinder. Note how the mirror is used to retract the tongue.

Fig. 2.9 Modified half cheek retractions deflect the upper lip to reveal the maxillary incisors and gingiva. A black photographic paddle placed behind the dentition creates contrast against the color of the teeth and highlights the contours of the incisal edges.

the photographer will confirm the final composition through the view finder before making the picture.

With the same modified cheek retractors as the occlusal view photographs, the ones with one wing completely removed (see Fig. 2.4), close-up photographs can be made from a frontal view of anterior teeth. To accent tooth incisal edge contours, a black contraster or modified autoclavable kitchen spatula[2] can be inserted in the mouth behind the teeth (Fig. 2.9).

DENTOFACIAL ANALYSIS

Facially generated tooth positions have found great esthetic and functional success in dentistry.[3–5] Historically, tooth positions were solely analyzed and determined from stone casts mounted on an articulator in CR. Reconstructions were governed with objectives to achieve a class 1 occlusion and have maximal intercuspation equal to centric occlusion to achieve optimal function. Known as functional reconstructions, mechanically, this proved very successful. However, in some situations, patients who were reconstructed with only a functional philosophy might have looked a little strange when an observer stepped back and viewed their entire face. Esthetic failures sometimes resulted simply because the lips were never considered during the analysis of the articulated diagnostic casts.[4] To address the relation of the face and the teeth, it is recommended to start the analysis with the esthetics of tooth position and then proceed to function, structure, and biology of the teeth.[6,7] Function is not ignored; it is still just as important, but in the work flow of planning the restorations, it follows after the esthetic considerations. Interestingly, when the esthetics are considered first in planning, function seems to naturally follow. Facial norms will be discussed next; however, it is important to recognize that the presented values do not govern patient treatment in an absolute manner. The numbers generated by research merely offer suggested guidelines that may prove quite helpful.

TABLE 2.1 Effect of Age on Amount of Anterior Tooth Display

Age	Maxillary Central Incisor (mm)	Mandibular Central Incisor (mm)
Up to 29	3.4	0.5
30–39	1.6	0.8
40–49	1.0	2.0
50–59	0.5	2.4
60+	−0.04	3.0

From Vig RG, Brundo GC. The kinetics of anterior tooth display. *J Prosthet Dent.* 1978;39:502–504.

Repose: The Starting Point

In an interdisciplinary team, the role of the restorative dentist is to identify where the teeth should be positioned to optimize esthetics, phonetics, and function. With a facially generated tooth position, the arrangement of teeth starts with the evaluation of the maxillary incisal edge to the resting upper lip, also known as the repose facial expression.[4] Vig and Brundo showed in a classic article that, as a person ages, the facial soft tissues tend to lose their elasticity which succumbs in a downward migration of the face on the skull. As a result of aging, less maxillary incisal is displayed when the lips were slightly separated in a resting position.[8] Conversely, as the maxillary anterior teeth become less visible in repose, the mandibular anterior teeth become more visible (Table 2.1). The resting facial expression is the optimal facial expression to determine the incisal edge position because of its static nature.[8–12]

Lip Form

An online survey was created to classify and define lip form and to evaluate the influence of lip form on dentists' and laypersons' preferences for the amount of incisal display with lips at rest. Three distinct lip forms were used. When evaluated between the commissures of the resting maxillary lip, lip form can follow a straight path or have a moderate or high vertical elevation.[13] Conclusions were drawn for when the lip form changed from straight to moderate to high, an increase of maxillary incisal display was preferred. Respondents' preference for male and

female amounts of incisal display were the same except more incisal display was favored for the females with a high lip form.[13] Although restorative dentists do not have control over lip form, clinicians do control the maxillary incisal edge position. It is important to understand that, as the maxillary lip gets shorter through a vertically curved arch pattern, it is natural to show more maxillary incisor.

Lips in Smile

Although a smile is a universal facial expression,[14] it is difficult to show high levels of evidence for objective measures for attractive or unattractive smiles because of subjective bias. At the treatment planning phase, one must recognize that smiles are dynamic facial expressions and have great variability within an individual that is closely linked to emotions.[14,15] Research has shown the importance of dental alignment[16,17] but not symmetry of the face because there are conflicting objective evaluations to qualify the summation of all the parts.[18] Furthermore, differences in opinions within dental professionals and patients exist on what is considered an acceptable amount of gingival display.[19–23] Consequently, smiles are open to subjective interpretation with cultural and individualized perceptions of beauty.[24,25]

Tjan et al developed a classic smile classification system of high, average, and low smiles. The high smile was defined as exhibiting the total cervicoincisal length of the maxillary anterior teeth and a contiguous band of gingiva.[26] Average smile revealed 75% to 100% of the maxillary anteriors plus the interproximal papillae. Smiles with less than 75% dental display were classified as low smile. It was also found that women tended to have a higher smile line than men.[26] Since then, other investigators have drawn the same conclusion about women having larger smiles than men.[27–29] In a multicenter interracial study, Owen et al reported that when smiling (African American, White, Chinese, Hispanic, Japanese, and Korean) women displayed significantly more gingival tissues in four of the six ethnic groups,[30] and African Americans displayed significantly more gingival tissues than any other ethnic group.[30]

More recent evaluation of papillae display in a smile found that the interdental soft tissue was visible in 91% of all individuals,[31] demonstrating the important role of the periodontal tissues in achieving excellent facial esthetics. Those who were classified as having a low gingival smile line displayed papillae 87% of the time.[31] Other researchers agree that gingival esthetics is far more important than previously realized. The aforementioned results are drastically different than the results of Tjan's high, average, and low smile line classification,[26] whose low smile line classification did not show gingival tissue and did show that the majority of patients' gingiva is a factor in facial esthetics that should be part of the dentofacial analysis.[31]

Smile Types

Guillaum-Benjamin Amand Duchenne, a 19th century French neurologist, is considered the first researcher to describe a difference between a sociable smile and a maximal or joyous smile through electrical stimulation of facial muscles of expression.[32] Later Charles Darwin agreed with Duchenne in that the joyous smile involved the contraction of both the zygomatic major muscles and the orbicularis oculi muscles.[33] Out of respect to the French neuroscientist, the true joyous smile has become to be known as the Duchenne smile.[14]

Ekman et al described three distinctly different smiles tied to independent emotions.[34] They described the Duchenne smile as a felt smile that was linked to positive emotions. A false smile is a facial expression that can be generated to deliberately attempt to appear positive; however, it is used to mask feelings of contempt or deceit. A miserable smile can be displayed when a person experiences pain, fear, or anxiety and an attempt to smile will show a will for survival. When the total face is evaluated and not just the smile, up to 50 different types of smiles have been identified.[35] This leaves a clinician with one question: When you ask your patient to smile, what type of smile is your patients giving you?

Dentists need to evaluate the morphologic and dynamic characteristics of a smile. Examples of morphologic keys with a Duchenne smile or maximal smile are an open mouth, raising of the cheeks, and wrinkling of the corners of the eyes.[36] Dynamics in smiles refers to the rate of temporal unfolding or velocity with which a smile begins and terminates. Duchenne smiles have larger amplitude, longer duration, and more abrupt onset and offset than do polite or embarrassed smile types.[37]

Because smiles can vary in both morphologic and dynamic qualities within one individual, it is important to note what type of smile the patient is producing so that a patient who can generate a high smile is not incorrectly classified as a medium or low smile type because they just happened to not produce their maximal smile. To minimize errors in categorizing patient smile types, it is important to remember to evaluate the eyes and confirm that there is contraction of the orbicularis oculi, which results in wrinkling at the corners of the eyes along with elevation of the middle third facial soft tissues.[36]

Esthetics in Speech

Some suggest that clinicians should view the dynamics of the anterior dentition with video recordings as a continuum delineated by time points of repose, speech, social smile, and Duchenne smile.[22–24]

With a spontaneous smile, the height of the upper lip is generally increased when compared with the lip height during speech.[38] Contrary to the maxilla, the mandibular anterior teeth are more visible during speech than during a smile.[39,40] In one study, 93% of the participants had their mandibular anteriors form part of an esthetic zone during speech.[39]

CEPHALOMETRIC ANALYSIS

Valuable craniomaxillofacial information can be gleaned from cephalometric data. A lateral cephalometric radiograph is a two-dimensional image of the head that captures the bones and soft tissue profile in the sagittal view. Traditionally, the image is made with a cephalostat, but this analysis can also be done with cone-beam computed tomography (CBCT) or magnetic resonance imaging (MRI).[41,42] If a dental patient's reconstruction needs a skeletal/soft-tissue analysis, care should be taken in ordering the image to minimize radiation exposure.[43] Anatomic landmarks

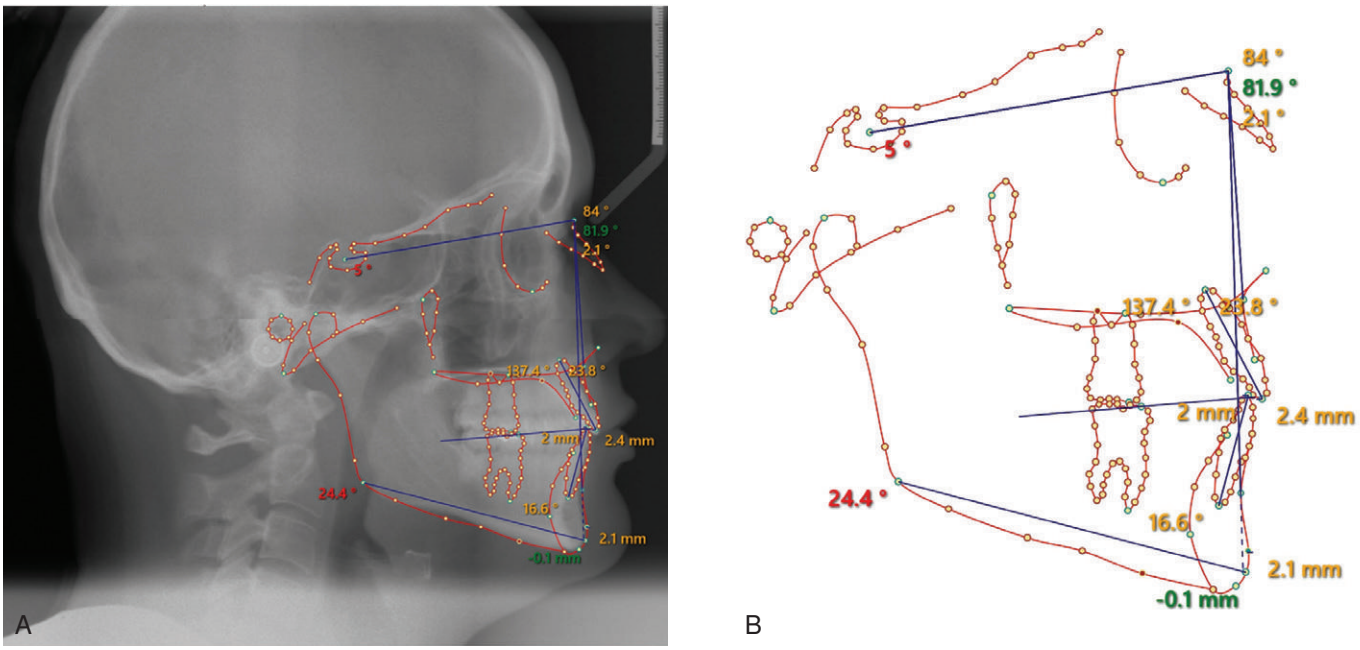

Fig. 2.10 (A) Cephalometric analysis. (Courtesy Todd Ehrler DDS, MS.) (B) Example of how measurements were obtained for the Steiner analysis in Table 2.2.

TABLE 2.2 Cephalometric Analysis[a]

Name	Value	Range
Skeletal Analysis		
SNA	84°	81.8 ± 3.7°
SNB	81.9°	79.2 ± 2.3°
ANB	2.1°	2.6 ± 2.4°
Dental Analysis		
Upper incisor to NA distance	2.4 mm	3.8 ± 2.7 mm
Upper incisor to NA angle	23.8°	21.4 ± 6.9°
Lower incisor to NB distance	2 mm	3.4 ± 3.6 mm
Lower incisor to NB angle	16.6°	22.4 ± 9.6°
Upper incisor to lower incisor angle	137.4°	133.6 ± 13°
Pogonion to NB distance	1.1 mm	2.1 ± 1.6 mm
Pogonion and lower incisor to NB difference	0.9 mm	2.6 ± 1.7 mm
Occlusal plane to SN angle	5°	14.4 ± 2.5°
Gonion-Gnathion to SN angle	24.4°	31.3 ± 3.1°

[a]Age: 37 years, 5 months; Timepoint: Initial 2019-12-10; Gender: F; Analysis: Steiner
Example of a cephalometric analysis. The red font indicates measurements that were outside of the established ranges.
ANB, A point–nasion–B point angle; *NA*, nasion-A point (subspinale); *NB*, nasion-B point (supramentale); *SN*, sella–nasion line; *SNA*, sella–nasion–A point angle; *SNB*, sella–nasion–B point angle.

have been defined and traced so that measurements and angles between the cranial base, maxilla, mandible, dentition, and facial soft tissue profile can be made (Fig. 2.10). The lateral cephalometric radiograph is a standardized image. Accordingly, population norms have been established so comparisons among individuals can be made (Table 2.2). Interpretation of a lateral cephalogram explains a patient's dentofacial proportions and helps to clarify if there is a skeletal discrepancy and/or a dental malocclusion. Many times, malocclusions that are caused with an underlying skeletal issue cannot be corrected with restorative dentistry alone. Hence, if during the planning phase a skeletal malocclusion is diagnosed, interdisciplinary treatment combining orthodontics and/or surgery may be indicated. Numerous cephalometric analyses exist to evaluate the craniofacial complex; however, one is not better than another. The data presented here are provided to quickly aid in the diagnostic process to help determine if a more in-depth comprehensive analysis may be necessary (Fig. 2.11).

DIGITAL SMILE DESIGN AND ESTHETIC TEMPLATES

In comprehensive dental care, one challenge has always been the communication of the vision of the treatment plan between the care provider(s) and patient.[6] Computer imaging offers the patient a virtual vision of what a proposed treatment plan has to offer and provides excellent communication between the patient and doctor (Fig. 2.12).[44–47]

A digital smile design or diagnostic tooth waxing can be converted to an esthetic template that fits over patients existing dentition.[48] In fixed prosthodontics, an esthetic template is equivalent to a denture wax clinical evaluation in removable prosthodontics. It can be designed and milled or three-dimensional (3D) printed with computer-aided design and computer-aided manufacturing (CAD-CAM) technologies or with traditional articulated casts and a diagnostic waxing. Traditionally, a silicone impression or a thermoplastic mold from a duplicated cast of the diagnostic waxing was used to transfer the new tooth forms intraorally with interim restorative resins. The esthetic template fits over the patient's unprepared

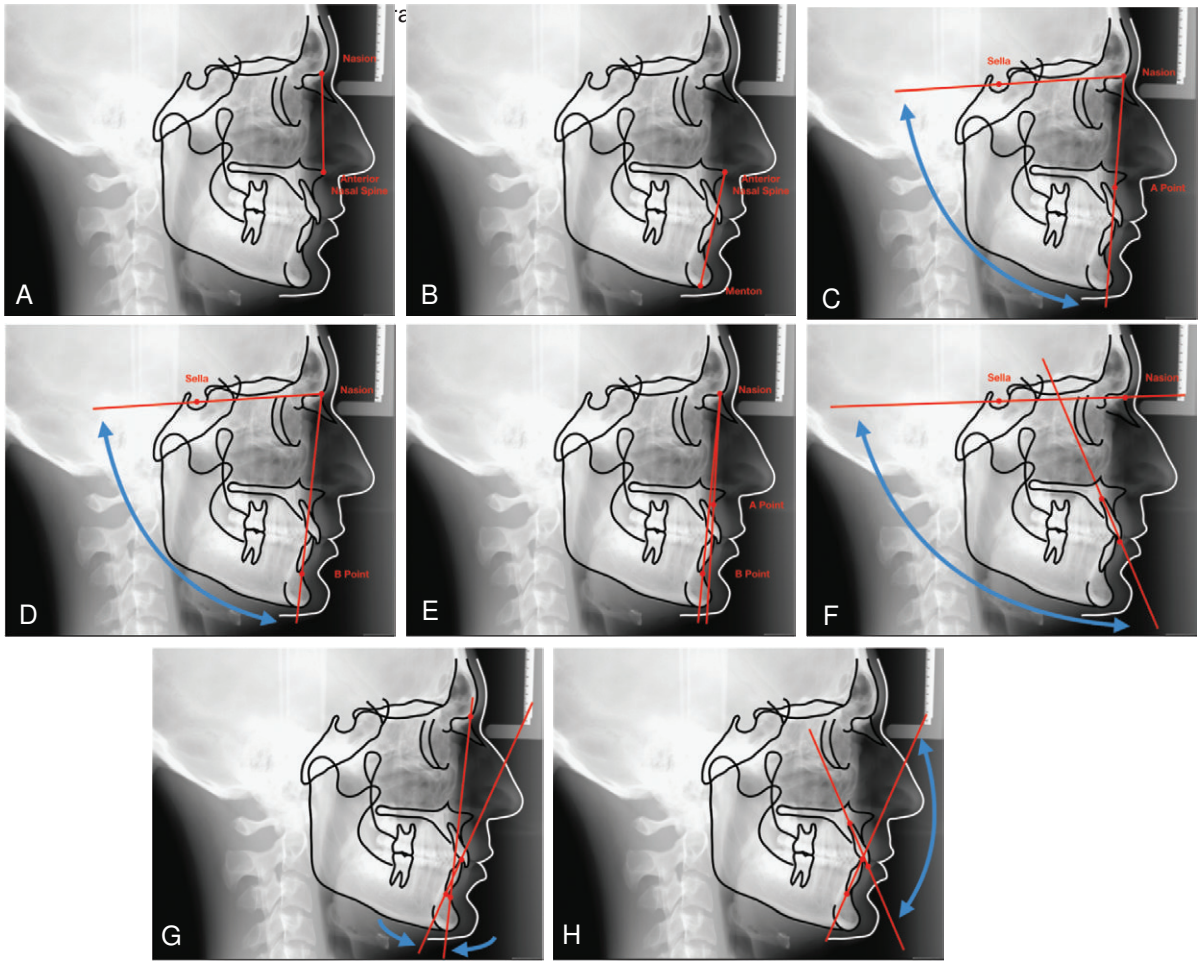

Fig. 2.11 (A and B) Anterior facial height is divided into an upper and lower face. The upper anterior face height (UAFH) (A) is a linear measurement between nasion and anterior nasal spine (N-ANS). The lower anterior face height (LAFH) (B) is a linear measurement between anterior nasal spine and menton (ANS-ME). The ratio between the upper and lower facial height (the UAFH/LAFH ratio) gives guidance on whether the lower face is long or short. The ration between the two facial heights is more relevant than the solitary individual measurements.

- UAFH/LAFH ratio <0.8 indicates a longer lower anterior facial height (LSFH)
- UAFH/LAFH ratio >0.8 portrays a shorter lower anterior facial height (LSFH)

(C) Sella-nasion-A point (SNA) is an angle that shows the horizontal position of the maxilla (A point) relative to the cranial base (sella-nasion).

- 82° ± 3° Average
- >85° indicates a prognathic maxilla
- <79° indicates a retrognathic maxilla

(D) Sella-nasion-B point (SNB) is an angle used to explain the anteroposterior position of the mandible relative to the cranial base. B point is marked at the most apical part of the alveolus and concave part of the mandibular symphysis.

- 80° ± 3° Average
- >83° indicates a prognathic mandible
- <77° indicates a retrognathic mandible

(E) ANB gives an angle for the relationship of the maxilla to the position to the mandible. (SNA) – (SNB) = ANB

- Average ranges between 1° and 5° indicate a skeletal Class I
- Positive value >5° for ANB is indicative of a Class II skeletal jaw relationship (i.e., maxilla anterior to mandible).
- Negative values or <1° ANB value means a Class III skeletal jaw relationship (i.e., maxilla posterior to mandible)

(F) Maxillary incisor (U1) to sella-nasion (SN) is the angle between the anterior cranial base and inclination of the central incisor.

- Average value = 103° ± 6°
- >109° indicates a proclined incisor (Class II division 1)
- <97° indicates a retroclined incisor (Class II division 2)

(G) Mandibular incisor (L1) to nasion-B point (NB) is used to communicate the mandibular incisor position to the mandibular alveolar base.

- Average angle 25° ± 7°
- >32° indicates a more proclined incisor (Class II division 1)
- <18° indicates an upright or retroclined incisor (Class II division 2)

(H) Maxillary incisor (U1) to mandibular incisor (L1) is an angle developed between the long axis of the maxillary and mandibular central incisors.

- Average angle 135° ± 11°
- >146° indicates that the incisors are more proclined (Class II division 2)
- <124° indicates that the incisors are more retroclined (Class II division 1)

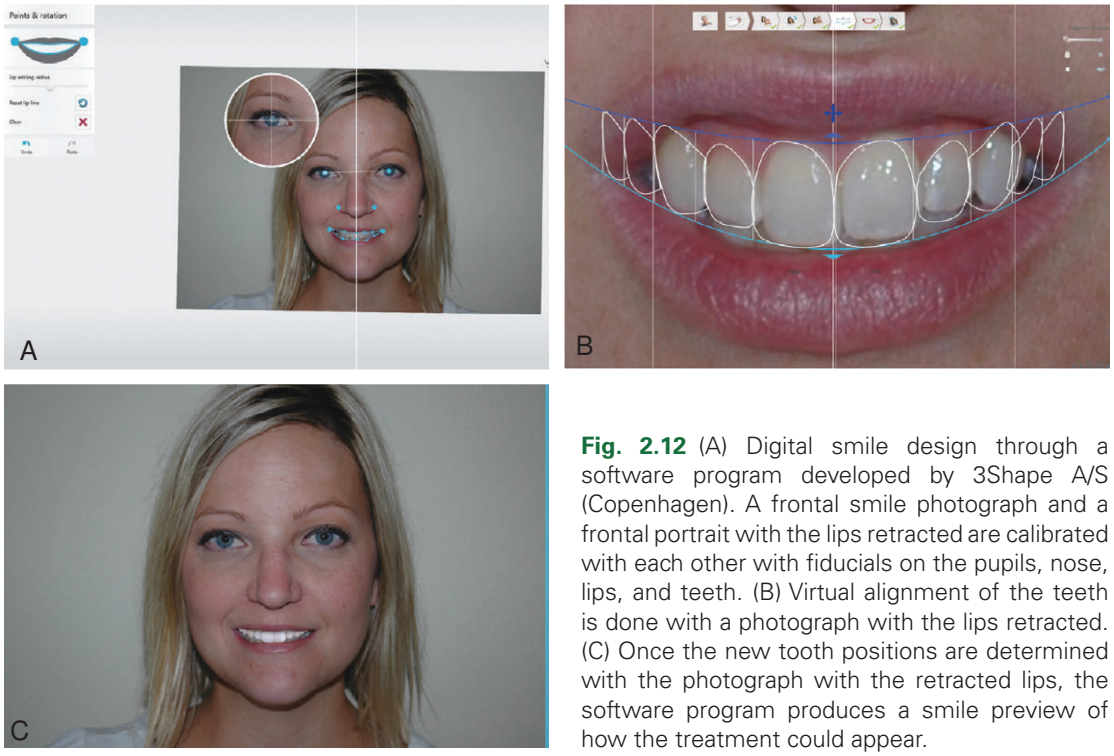

Fig. 2.12 (A) Digital smile design through a software program developed by 3Shape A/S (Copenhagen). A frontal smile photograph and a frontal portrait with the lips retracted are calibrated with each other with fiducials on the pupils, nose, lips, and teeth. (B) Virtual alignment of the teeth is done with a photograph with the lips retracted. (C) Once the new tooth positions are determined with the photograph with the retracted lips, the software program produces a smile preview of how the treatment could appear.

teeth so the dentist can evaluate the proposed treatment in real time with the patient's face (Fig. 2.13). As a reversible procedure, the function of the lips can be assessed before treatment is started. Once the accuracy of the proposed treatment is confirmed, the patient can evaluate the esthetic template and take it home for further evaluation with friends and family. Video recordings can also be helpful to assess the facial functional effect with different facial expressions and phonetics while wearing an esthetic template.

DIAGNOSTIC CASTS AND RELATED PROCEDURES

Accurate diagnostic casts, whether in a digital format or transferred to a traditional analog semiadjustable articulator (Figs. 2.14 and 2.15), are essential in planning fixed prosthodontic treatment. This enables examination of static and dynamic relationships of the teeth without interference from protective neuromuscular reflexes, and unencumbered views from all directions reveal aspects of the occlusion not always easily detectable intraorally (e.g., the relationship of the lingual cusps in the occluded position). If the maxillary cast has been transferred with a facebow, a CR interocclusal record has been used for articulation of the mandibular cast, and the condylar elements have been appropriately set (as with protrusive and excursive interocclusal records), reproducing the patient's movements with reasonable accuracy is possible. If the casts have been articulated in CR, both the CR and the MI position can be assessed because any slide can then be reproduced.

Other critical information not immediately apparent during the clinical examination includes the occlusocervical dimension of edentulous spaces. On an articulator, these are readily assessed in the occluded position and throughout the entire range of mandibular movement. Relative alignment and angulation of proposed abutment teeth are easier to evaluate on casts than intraorally, as are many other subtle changes in individual tooth position. Articulated diagnostic casts enable a detailed analysis of the occlusal plane and the occlusion, and diagnostic procedures can be performed for a better diagnosis and treatment plan; tooth preparations can be "rehearsed" on the casts, and diagnostic waxing procedures allow evaluation of the eventual outcome of the proposed treatment.

IMPRESSION MAKING FOR DIAGNOSTIC CASTS

Accurate digital scans or traditional impressions of both dental arches are required. Saliva or foreign debris on the occlusal surfaces of optical scans are interpreted as hard contours of the teeth and result in errors in articulation. Flaws in the traditional impressions result in inaccuracies in the casts that easily multiply. For instance, a small void in the impression caused by the trapping of an air bubble on one of the occlusal surfaces results in a nodule on the occlusal table. If it is not recognized and carefully removed, it leads to an inaccurate articulator mounting, and the diagnostic data are incorrect.

As long as the optical scan or traditional impression extends several millimeters beyond the cervical line of the teeth, the borders of diagnostic impressions are usually not of great concern