tenth edition

McDONALD AND AVERY'S DENTISTRY for the CHILD and ADOLESCENT

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Foreword

As we entrust the continuing editions of this textbook to others, we reflect on the many rewards we have realized by our participation in the previous editions. The personal rewards have been many but the more important result is the positive impact that the previous printings have hopefully had on students, colleagues who teach and/or practice pediatric dentistry, and most importantly their patients.

Dental technology has advanced immeasurably in the 50 years that these publications have been available. At that time the efficacy of fluoridated dentifrices had recently been recognized as a safe and effective adjunct to dental caries prevention. Communal water fluoridation was also relatively new. Both of these exceptional caries prevention services were viewed skeptically by many.

Continued

The late Dr. Ralph E. McDonald *(seated)* with Dr. Jeffrey A. Dean *(left)* and Dr. David R. Avery *(right),* pictured with all nine editions of *McDonald and Avery's Dentistry for the Child and Adolescent* displayed on the desktop.

Today they are accepted by the majority of the scientific community. Only 30 years ago dental amalgam was still the mainstay of restorative dentistry, preformed and festooned stainless steel crowns had just been introduced, and composite resins were in their infancy. Today the crowns and esthetic materials dominate the restorative services provided in pediatric dentistry. Similarly, significant changes in the standards of care and the increased level of our knowledge are reflected in every chapter of this tenth edition.

The senior members of our profession recognize that the technologic advancements and accepted practice norms have dramatically changed our approach to patient care over the past few decades. Virtually every aspect of patient therapy has been affected. We also acknowledge that the advancements are now growing exponentially. However, the ultimate goal of providing the highest quality service to patients remains the same.

Although our publication goal has been to make a positive contribution to our profession and ultimately to its patients, no one has benefited from our efforts more than we have. Regular new editions required us to update our base of knowledge from additions in the scientific literature and from exchanging experiences with our colleagues, including students. Constructive suggestions and criticisms from our colleagues have also strengthened the textbook from one edition to the next. Other noteworthy rewards for us have been the many hugs of appreciation we have received from our own grateful patients as we provided the care that we espoused.

Listing every individual who has helped us over the years of these publications is impractical. Suffice it to say that we are most appreciative to all our colleagues and students, patients, friends, and family who have supported our efforts in myriad ways.

Finally, we wish Godspeed to Drs. Dean, Jones, Vinson, and all other future contributors as they proceed with this work of love. We have the utmost confidence in their abilities to carry on.

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*Unfortunately, Dr. McDonald passed away shortly after the Foreword was written and only months prior to the first printing of the tenth edition. We are all terribly saddened by this loss and will miss him dearly.

Preface

With this publication of the textbook, we are entering a historic milestone with the first "double digit" edition of the title *Dentistry for the Child and Adolescent*. As I write this, I am holding Dr. Ralph McDonald's very first book entitled *Pedodontics: The Postgraduate Dental Lecture Series*, which he developed early in his career as a professor of pediatric dentistry. This book was published by the CV Mosby Company in 1963 and had 11 chapters, complemented with 245 illustrations. The copy I am holding in my hand was Dr. McDonald's personal copy and has many handwritten entries in it. What a treasure!

Although his 1963 first text is known by a different title, it clearly is the foundation of our current series. In fact, all 11 chapter titles in this 1963 edition can be found in some form or another in the current text. As you may have noticed, this therefore represents the 50th celebratory anniversary for this classic pediatric dentistry textbook. Dr. McDonald and Dr. David Avery, who joined him in writing the last seven editions, certainly have left their mark on our specialty with this work, and it's a unique honor and pleasure for me to be able to help continue the series now and hopefully into the future. One can certainly reflect on the perhaps millions of children who these two grand gentlemen were able to directly assist by continuing to provide the latest theories, research, concepts, and techniques to practitioners around the world.

So what changes have we made to this edition? First and foremost is the bowing out of both Drs. McDonald and Avery as editors of the book. While I stayed in regular communications with them during the production, they were not actively engaged in writing or editing. Their involvement was definitely missed by me. In addition, many other contributors have moved on with retirements and other life transitions and are no longer involved. Although we are all sad to see them go, their departure opened up exciting opportunities for new expert contributors to become involved. And I can say, I was very fortunate to successfully recruit wonderful new authors.

In addition to all of the new contributors to the text, as well as the electronic version having questions and answers with each chapter, we have also included a case study or two for each chapter, as well as 10 video vignettes to enhance the learning experience for students. These are significant improvements that we hope you will find most enjoyable. They are available on the Elsevier Evolve website.

Whereas I am very pleased to point out that we have rearranged the text into five major areas of focus, I hope that you will notice that the same excellent chapter titles are promulgated in this tenth edition. The new five areas of focus will help the practitioner and student as they organize their thinking and practice around these concepts. In addition to this new organization, we continue to attempt to replace all illustrations with color and have made significant improvements in this area.

The fundamental essence of the textbook is retained, such that the information contained herein remains relevant to the contemporary science and practice of pediatric dentistry. It is designed to help predoctoral and postdoctoral pediatric dental students provide efficient and superior comprehensive oral health care to infants, children, teenagers, and medically compromised patients. It also provides experienced dentists with reference information regarding new developments and techniques.

Once again, please join me in celebrating the fiftieth anniversary of this textbook series! In assuming the role of editor, I hope I have done justice to the previous work of both Drs. McDonald and Avery. I look forward to receiving feedback from you as you have a chance to peruse the book and as we look forward to continuing the tradition of excellence in pediatric dental education and practice. My sincerest appreciation to all of our past author contributors—and especially to our continuing and our new author contributors—for all of their dedication and work on this anniversary edition!

Jeffrey A. Dean

Acknowledgments

A textbook can be planned and written only with the supportive interest, encouragement, and tangible contributions of many people. Therefore it is a privilege to acknowledge the assistance of others in the preparation of this fiftieth anniversary and tenth edition of the text. First and foremost, of course, I must acknowledge the tremendous contributions and mentorship of both Doctors Ralph McDonald and David Avery. As I mentioned in the preface, their contributions to this edition are missed, but I know that their guidance and mentoring of me during my contributions over the last four editions helped me tremendously as I assumed my new role as chief editor. They both served as tremendous role models and supporters throughout my career.

Next, I wish to acknowledge the contributions of my two associate editors, Dr. James Jones and Dr. LaQuia Vinson. Dr. Jones has contributed to this textbook for many editions, and in particular in this past edition has done anything I've asked to help make sure that we provided a timely and relevant product. Dr. Vinson is a new contributor, brings fresh perspectives, and in particular worked diligently on various aspects of the book. In addition, I'd like to thank Dr. Juan Yepes for taking on the task of making multiple video vignettes that will complement the online version of the textbook.

I would certainly like to take the opportunity to thank the many authors and co-authors who made this tenth edition possible. Specifically, I need to thank and acknowledge the contributions in previous editions by authors who did not participate this time: Drs. Gerald Wright, Dale Miles, David Bixler†, Murray Dock, Keith Moore, Robert Feigal†, Robert Cronin, Charles Goodacre, Thomas Lapp, Ronald Bell†, Michael Sadove, Ann Page Griffin, Jasper Lewis, and Charles Hutton. My hat's off to them for their previous contributions! In addition, special recognition goes to Dr. Rolando DeCastro for his many wonderful illustrations and cover art over the years. Donna Bumgardner once again provided manuscript preparation and valuable editorial assistance for our work, including serving as a bit of a taskmaster to make sure we stayed on track. Mark Dirlam, Kyla Jones, Terry Wilson, and Tim Centers provided assistance with new illustrations. We also gratefully acknowledge the professional staff at Elsevier who has provided valuable assistance and superb guidance in the preparation of this tenth edition, with special thanks to Kathy Falk, executive content specialist; Brian Loehr, senior content development specialist; and Sharon Corell, senior project manager. The faculties of pediatric dentistry and other disciplines at Indiana University have contributed substantially to this work in many ways. We truly appreciate their willingness to share information relevant to scientific accuracy of the manuscripts. Many pediatric dentistry postdoctoral students and auxiliary staff also assisted in numerous ways.

With this special anniversary edition I would like to take the privilege and follow the lead of Dr. McDonald, as he did in his very first edition of this series back in 1963, to thank my family for their patience, love, and support throughout this project and always.

Jeffrey A. Dean

†Deceased

PART 1 DIAGNOSES

CHAPTER 1

Examination of the Mouth and Other Relevant Structures

▲ Jeffrey A. Dean

For additional resources, please visit the evolve website.

CHAPTER OUTLINE

EMERGENCY DENTAL TREATMENT

A dentist is traditionally taught to perform a complete oral examination of the patient and to develop a treatment plan based on the examination findings. The dentist then makes a case presentation to the patient or parents, outlining the recommended course of treatment. This process should include the development and presentation of a prevention plan that outlines an ongoing comprehensive oral health care program for the patient and establishment of the "dental home."

The plan should include recommendations designed to correct existing oral problems (or halt their progression) and to prevent anticipated future problems. It is essential to obtain all relevant patient and family information, to secure parental consent, and to perform a complete examination before embarking on this comprehensive oral health care program for the pediatric patient. *Anticipatory guidance* is the term often used to describe the discussion and implementation of such a plan with the patient and/or parents. The American Academy of Pediatric Dentistry has published guidelines[1] concerning the periodicity of examination, preventive dental services, and oral treatment for children as summarized in Table 1-1.

Each pediatric patient should be given an opportunity to receive complete dental care. The dentist should not attempt to decide what the child, the parents, or a third-party agent will accept or can afford. If parents reject a portion or all of the recommendations, the dentist has at least fulfilled the obligation of educating the child and the parents about the importance of the recommended procedures. Parents with even moderate income usually find the means to have oral health care performed if the dentist explains that the child's future oral health and even general health are related to the correction of the oral defects.

INITIAL PARENTAL CONTACT WITH THE DENTAL OFFICE

We most often think of parents' first contact with the dental office as being by telephone. This initial conversation between the parent and the office receptionist is very important. It provides the first opportunity for the receptionist to attend to the parents' concerns by pleasantly and concisely responding to questions and by offering an office appointment. The receptionist must have a warm, friendly voice and the ability to communicate clearly. The receptionist's responses should assure the parent that the well-being of the child is the chief concern.

The information recorded by the receptionist during this conversation constitutes the initial dental record for the patient. Filling out a patient information form is a

Table 1-1

Recommendations for Pediatric Oral Health Assessment, Preventive Services, and Anticipatory Guidance/Counseling

Since each child is unique, these recommendations are designed for the care of children who have no contributing medical conditions and are developing normally. These recommendations will need to be modified for children with special health care needs or if disease or trauma manifests variations from normal. The American Academy of Pediatric Dentistry (AAPD) emphasizes the importance of very early professional intervention and the continuity of care based on the individualized needs of the child. Refer to the text of this guideline for supporting information and references. Refer to the text in the Guidelines on Periodicity of Examinations, Preventive Dental Services, Anticipatory Guidance, and Oral Treatment for Infants, Children, and Adolescents (www.aapd.org/media/Policies_Guidelines/G_Periodicity.pdf) for supporting information and references.

	AGE				
American Academy of Pediatric Dentistry	6 to 12 months	12 to 24 months	2 to 6 years	6 to 12 years	12 years and older
Clinical oral examination[1]	•	•	•	•	•
Assesses oral growth and development[2]	•	•	•	•	•
Caries-risk assessment[3]	•	•	•	•	•
Radiographic assessment[4]	•	•	•	•	•
Prophylaxis and topical fluoride[3,4]	•	•	•	•	•
Fluoride supplementation[5]	•	•	•	•	•
Anticipatory guidance/counseling[6]	•	•	•	•	•
Oral hygiene counseling[7]	Parent	Parent	Patient/ parent	Patient/ parent	Patient
Dietary counseling[8]	•	•	•	•	•
Injury prevention counseling[9]	•	•	•	•	•
Counseling for nonnutritive habits[10]	•	•	•	•	•
Counseling for speech/language development	•	•	•	•	•
Assessment and treatment of developing malocclusion			•	•	•
Assessment for pit and fissure sealants[11]			•	•	•
Substance abuse counseling				•	•
Counseling for intraoral/perioral piercing				•	•
Assessment and/or removal of third molars					•
Transition to adult dental care					•

[1]First examination at the eruption of the first tooth and no later than 12 months. Repeat every 6 months or as indicated by child's risk status/susceptibility to disease. Includes assessment of pathology and injuries.
[2]By clinical examination.
[3]Must be repeated regularly and frequently to maximize effectiveness.
[4]Timing, selection, and frequency determined by child's history, clinical findings, and susceptibility to oral disease.
[5]Consider when systemic fluoride exposure is suboptimal. Up to at least 16 years of age or later in high-risk patients.
[6]Appropriate discussion and counseling should be an integral part of each visit for care.
[7]Initially, responsibility of parent; as child matures, jointly with parent; then, when indicated, only child.
[8]At every appointment; initially discuss appropriate feeding practices, followed by the role of refined carbohydrates and frequency of snacking in caries development and childhood obesity.
[9]Initially for play objects, pacifiers, car seats; then while learning to walk; and then with sports and routine playing, including the importance of mouthguards.
[10]At first, discuss the need for additional sucking: digits vs. pacifiers; then the need to wean from the habit before malocclusion or skeletal dysplasia occurs. For school-aged children and adolescent patients, counsel regarding any existing habits such as fingernail biting, clenching, or bruxism.
[11]For caries-susceptible primary molars, permanent molars, premolars, and anterior teeth with deep pits and fissures; placed as soon as possible after eruption.

convenient method of collecting the necessary initial information. Of course, most dental practices are moving toward online, website-driven information and completion of patient forms for use even before a parent calls an office for an appointment or schedules an appointment online. Practices need to make accommodations to their patient information systems to manage these very productive changes.

THE DIAGNOSTIC METHOD

Before making a diagnosis and developing a treatment plan, the dentist must collect and evaluate the facts associated with the patient's or parents' chief concern and any other identified problems that may be unknown to the patient or parents. Some pathognomonic signs may lead to an almost immediate diagnosis. For example, obvious gingival swelling and drainage may be associated with a single, badly carious primary molar. Although these associated facts are collected and evaluated rapidly, they provide a diagnosis only for a single problem area. On the other hand, a comprehensive diagnosis of all of the patient's problems or potential problems may sometimes need to be postponed until more urgent conditions are resolved. For example, a patient with necrotizing ulcerative gingivitis or a newly fractured crown needs immediate treatment, but the treatment will likely be only palliative, and further diagnostic and treatment procedures will be required later.

The importance of thorough collection and evaluation of the facts concerning a patient's condition cannot be overemphasized. A thorough examination of the pediatric dental patient includes an assessment of the following:

- General growth and health
- Chief complaint, such as pain
- Extraoral soft tissue and temporomandibular joint evaluation
- Intraoral soft tissue
- Oral hygiene and periodontal health
- Intraoral hard tissue
- Developing occlusion
- Caries risk
- Behavior

Additional diagnostic aids are often also required, such as radiographs, study models, photographs, pulp tests, and, infrequently, laboratory tests. In certain unusual cases, all of these diagnostic aids may be necessary before a comprehensive diagnosis can be made. Certainly no oral diagnosis can be complete unless the diagnostician has evaluated the facts obtained by medical and dental history taking, inspection, palpation, exploration (if teeth are present), and often imaging (e.g., radiographs). For a more thorough review of evaluation of the dental patient, refer to the chapter by Glick, Greenberg, and Ship in *Burket's Oral Medicine*.[2]

PRELIMINARY MEDICAL AND DENTAL HISTORY

It is important for the dentist to be familiar with the medical and dental history of the pediatric patient. Familial history may also be relevant to the patient's oral condition and may provide important diagnostic information in some hereditary disorders. Before the dentist examines the child, the dental assistant can obtain sufficient information to provide the dentist with knowledge of the child's general health and can alert the dentist to the need for obtaining additional information from the parent or the child's physician. The form illustrated in Figure 1-1 can be completed by the parent. However, it is more effective for the dental assistant to ask the questions informally and then to present the findings to the dentist and offer personal observations and a summary of the case. The questions included on the form will also provide information about any previous dental treatment.

Information regarding the child's social and psychological development is important. Accurate information reflecting a child's learning, behavioral, or communication problems is sometimes difficult to obtain initially, especially when the parents are aware of their child's developmental disorder but are reluctant to discuss it. Behavior problems in the dental office are often related to the child's inability to communicate with the dentist and to follow instructions. This inability may be attributable to a learning disorder. An indication of learning disorders can usually be obtained by the dental assistant when asking questions about the child's learning process; for example, asking a young school-aged child how he or she is doing in school is a good lead question. The questions should be age-appropriate for the child.

If a young child was hospitalized previously for general anesthetic and surgical procedures, it should be noted. Hospitalization and procedures involving general anesthesia can be a traumatic psychological experience for a preschool child and may sensitize the youngster to procedures that will be encountered later in a dental office.[3] If the dentist is aware that a child was previously hospitalized or that the child fears strangers in clinic attire, the necessary time and procedures can be planned to help the child overcome the fear and accept dental treatment.

Occasionally, when the parents report significant disorders, it is best for the dentist to conduct the medical and dental history interview. When the parents meet with the dentist privately, they are more likely to discuss the child's problems openly, and there is less chance for misunderstandings regarding the nature of the disorders. In addition, the dentist's personal involvement at this early time strengthens the parents' confidence. When an acute or chronic systemic disease or anomaly is indicated, the dentist should consult the child's physician to learn the status of the condition, the long-range prognosis, and the current drug therapy.

When a patient's medical and dental history is recorded, the presence of current illnesses or history of relevant disorders signals the need for special attention. In addition to consulting the child's physician, the dentist may decide to record additional data concerning the child's current physical condition, such as blood pressure, body temperature, heart sounds, height and weight, pulse, and respiration. Before treatment is initiated, certain laboratory tests may be indicated, and special precautions may be necessary. A decision to provide treatment in a

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705 Riley Hospital Drive, Room #4205
Indianapolis, IN 46202-5109
317.944.3865 office | 317.944.9653 fax
www.pediatricdentistryassociates.org

DOB: EDR:
NA:
LC: DATE:

MEDICAL / DENTAL HISTORY

Patient Name:_____ Birth Date:_____ Gender: ☐Female ☐Male
City & State of Birth:_____ Race:_____ Height:_____ Weight____
Primary Care Physician:_____ Previous Dentist: _____
Physician Address:_____ Dentist Phone:_____
Physician Phone:_____ Last Dental Visit: _____
Date of Last Medical Exam:_____ Last Dental X-rays:_____

Dental History:
What is the primary reason for today's visit? _____
Is patient in pain? ☐YES ☐NO Explain:_____
Has patient had an injury to the mouth, teeth, or jaw? ☐YES ☐NO Explain:_____
What is patient's primary water source: ☐ Private Well ☐ City Water, City Name:_____ ☐Other:_____
Was/is patient ☐ Breastfed or ☐ Bottle-fed Until what age? Breastfed:_____ Bottle-fed:_____
How often does patient brush teeth?_____ ☐With Help ☐Without Help How often does patient floss?_____
Does patient…

Yes / No		Yes / No		Yes / No	
☐	☐ Suck Thumb/Fingers	☐	☐ Bite/Chew Finger Nails	☐	☐ Clench/Grind Teeth
☐	☐ Use Pacifier	☐	☐ Have Speech Issues	☐	☐ Mouth Breather

Medical History:
Is patient currently under the care of a doctor? ☐YES ☐NO Explain:_____
Does patient have allergies? ☐YES ☐NO Explain:_____
Is patient taking medications? ☐YES ☐NO Please list all medications and natural remedies. Additional items may be listed on the back

Medication Name:	Dose:	Frequency of Use:

Has patient had surgery or been hospitalized? ☐YES ☐NO

Hospital Facility:	When:	Reason:

Does patient have / or had any of the following:

Yes / No		Yes / No		Yes / No	
☐	☐ Congenital Heart Defect/Disease	☐	☐ Visual/Hearing Impairment	☐	☐ Failure to Thrive
☐	☐ Heart Surgery	☐	☐ Abnormal Bleeding Issues	☐	☐ Eating Disorders
☐	☐ Heart Murmur	☐	☐ Sickle Cell Trait/Disease	☐	☐ Born Prematurely
☐	☐ High Blood Pressure	☐	☐ Hemophilia	☐	☐ Immunizations
☐	☐ Rheumatic Fever	☐	☐ Anemia	☐	☐ Hepatitis A, B, C
☐	☐ Asthma/Breathing Issues	☐	☐ Kidney Problems	☐	☐ Blood/Blood Product Transfusion
☐	☐ Cerebral Palsy	☐	☐ Liver Problems	☐	☐ HIV/AIDS
☐	☐ Seizures/Convulsions/Epilepsy	☐	☐ Diabetes	☐	☐ Varicella Vaccine / Chicken Pox
☐	☐ Learning/Communication Problems	☐	☐ Muscle/Joint/Bone Problems	☐	☐ TB / Tuberculosis
☐	☐ Autism	☐	☐ Thyroid/Glandular Problems	☐	☐ MRSA
☐	☐ ADD/ADHD	☐	☐ Skin Problems / Hives / Cold Sores	☐	☐ Limited Mobility

I affirm that the information provided above is correct to the best of my knowledge. It will be held in confidence and it is my responsibility to inform this office if there is a change in the health history of this patient. I authorize the release of this information to additional healthcare providers as is necessary for the dental treatments of this patient.

Guardian Signature:_____ Relationship to Patient:_____
Resident Signature: _____ Date:_____ Time:_____

Form #UPDDR217 Rev. 12/2013

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Figure 1-1 Form used in completing the preliminary medical and dental history. (Printed with permission from Indiana University–University Pediatric Dentistry Associates.)

hospital that possibly involves general anesthesia may be appropriate.

The dentist and the staff must also be alert to identify potentially communicable infectious conditions that threaten the health of the patient and others. Knowledge of the current recommended childhood immunization schedule is helpful. It is advisable to postpone nonemergency dental care for a patient exhibiting signs or symptoms of acute infectious disease until the patient recovers. Further discussions of management of dental patients with special medical, physical, or behavioral problems are presented in Parts III and V.

The pertinent facts of the medical history can be transferred to the oral examination record (Fig. 1-2) for easy reference by the dentist. A brief summary of important medical information serves as a convenient reminder to the dentist and the staff, who will refer to this chart at each treatment visit.

The patient's dental history should also be summarized on the examination chart. This should include a record of previous care in the dentist's office and the facts related by the patient and parent(s) regarding previous care, if any, in another office. Information concerning the patient's current oral hygiene habits and previous and current fluoride exposure helps the dentist develop an effective dental disease prevention program. For example, if the family drinks well water, a sample may be sent to a water analysis laboratory to determine the fluoride concentration.

CLINICAL EXAMINATION

Most facts needed for a comprehensive oral diagnosis in the young patient are obtained by thorough clinical and radiographic examination. In addition to examining the oral cavity structures, the dentist may in some cases wish to note the patient's size, stature, gait, or involuntary movements. The first clue to malnutrition may come from observing a patient's abnormal size or stature. Similarly, the severity of a child's illness, even if oral in origin, may be recognized by observing a weak, unsteady gait of lethargy and malaise as the patient walks into the office. All relevant information should be noted on the oral examination record (see Fig. 1-2), which becomes a permanent part of the patient's chart.

The clinical examination, whether the first examination or a regular recall examination, should be all-inclusive. The dentist can gather useful information while getting acquainted with a new patient. Attention to the patient's hair, head, face, neck, and hands should be among the first observations made by the dentist after the patient is seated in the chair.

The patient's hands may reveal information pertinent to a comprehensive diagnosis. The dentist may first detect an elevated temperature by holding the patient's hand. Cold, clammy hands or bitten fingernails may be the first indication of abnormal anxiety in the child. A callused or unusually clean digit suggests a persistent sucking habit. Clubbing of the fingers or a bluish color in the nail beds suggests congenital heart disease, which may require special precautions during dental treatment.

Inspection and palpation of the patient's head and neck are also indicated. Unusual characteristics of the hair or skin should be noted. The dentist may observe signs of problems such as head lice (Fig. 1-3), ringworm (Fig. 1-4), or impetigo (Fig. 1-5) during the examination. Proper referral is indicated immediately, because these conditions are contagious. After the child's physician has supervised treatment to control the condition, the child's dental appointment may be rescheduled. If a contagious condition is identified but the child also has a dental emergency, the dentist and the staff must take appropriate precautions to prevent spread of the disease to others while the emergency is alleviated. Further treatment should be postponed until the contagious condition is controlled.

Variations in the size, shape, symmetry, or function of the head and neck structures should be recorded. Abnormalities of these structures may indicate various syndromes or conditions associated with oral abnormalities.

TEMPOROMANDIBULAR EVALUATION

Okeson[4] published a special report on temporomandibular disorders in children. Okeson indicated that, although several studies included children 5 to 7 years of age, most observations have been made in young adolescents. Studies have placed the findings into the categories of symptoms or signs—those reported by the child or parents and those identified by the dentist during the examination. Prevalence of signs and symptoms increases with age and may occur in 30% of patients.

One should evaluate temporomandibular joint (TMJ) function by palpating the head of each mandibular condyle and by observing the patient while the mouth is closed (teeth clenched), at rest, and in various open positions (Fig. 1-6, *A, B*). Movements of the condyles or jaw that do not flow smoothly or that deviate from the expected norm should be noted. Similarly, any crepitus that may be heard or identified by palpation as well as any other abnormal sounds should be noted. Sore masticatory muscles may also signal TMJ dysfunction. Such deviations from normal TMJ function may require further evaluation and treatment. There is a consensus that temporomandibular disorders in children can be managed effectively by the following conservative and reversible therapies: patient education, mild physical therapy, behavioral therapy, medications, and occlusal splints.[5]

Discussion of the diagnosis and treatment of complex TMJ disorders is available from many sources; we suggest Okeson's *Management of Temporomandibular Disorders and Occlusion* (2013).[6]

The extraoral examination continues with palpation of the patient's neck and submandibular area (see Fig. 1-6, *C, D*). Again, deviations from normal, such as unusual tenderness or enlargement, should be noted and follow-up tests performed or referrals made as indicated.

If the child is old enough to talk, speech should be evaluated. The positions of the tongue, lips, and perioral musculature during speech, while swallowing, and at rest may provide useful diagnostic information.

The intraoral examination of a pediatric patient should be comprehensive. There is a temptation to look first for

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Indianapolis, IN 46202-5200
(317) 274-3865 ▪ (317) 274-9653 Fax

Place Patient Label Here

Patient Name:_____ (Last / First / MI)
OFFICE USE ONLY
DOB_____ Record #: _____

ORAL EXAMINATION RECORD

Address: Same ☐ New ☐ _____ Telephone: Same☐ New☐ _____
**** New address and/or phone number must be noted here and updated in practice software.*

MEDICAL HISTORY SUMMARY
Last History Completed: _____ Update Due: _____ Weight: _____
Current Medication Status & Medication Usage:

DENTAL HISTORY SUMMARY
Date of Last Exam: _____ Last Radiographs: B.W.: _____ A.O.:_____ P.A.:_____ F.M.:_____
Appliances: _____ Last Cemented: _____ Last Replaced: _____
Description of Present Problem:
Summary of Prior Treatment:

EXTRA-ORAL FINDINGS
Head: Neck:
Face: Lips: Hands:

INTRA-ORAL FINDINGS
Palate and Oropharynx: Airway: I II III IV
Tongue and Floor of Mouth: Buccal Mucosa:
Frena: Gingivae and Periodontium:

OCCLUSION REVIEW
Facial Profile: _____

Molar Relationship:

PRIMARY (Terminal Plane):	R	L	PERMANENT:	R	L
Straight	☐	☐	Molar		
Mes. Step	☐	☐	End to End	☐	☐
Dist. Step	☐	☐	Class	___	___
Primate Space	☐	☐	Canine		
Canine Relationship	___	___	Relationship	___	___

Midline: Normal ☐ Deviated ☐
Maxilla _____mm R☐ L☐
Mandible _____mm R☐ L☐
Mandibular:
Shift R☐ L☐ Ant. ☐_____mm

Incisor Relationship:
Overjet _____mm
Overbite _____%
Openbite _____mm

Arch Length: (General Impression)

Maxilla	Mandible
Adequate ☐	Adequate ☐
Inadequate ☐	Inadequate ☐

Eruption Sequence & Timimg:
Normal ☐ Describe ☐
_____
_____

TMJ and Function:
Opening Path: Normal ☐ Deviated ☐
Closing Path: Normal ☐ Deviated ☐
Opening: ____mm Normal ☐ Limited ☐

Joint Sounds:	None	Left	Right
Opening	☐	☐	☐
Closing	☐	☐	☐
Crepitus	☐	☐	☐

Muscle Tenderness:
Tongue Function:
Crossbite:
Oral Habits:
Analysis Recommended: YES☐ NO☐

Supernumerary Teeth/ Congenitally Missing Teeth:
Ectopic Eruption:
Other Anomalies:

Figure 1-2 Chart used to record the oral findings and the treatment proposed for the pediatric patient. (Printed with permission from Indiana University–University Pediatric Dentistry Associates.)

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ORAL EXAM RECORD

Patient Name: _____

Date of Birth: _____ ACT#: _____

HARD TISSUE EXAMINATION

		Clinical	Radiographic			Clinical	Radiographic
	1				16		
	2				15		
	3				14		
A	4			J	13		
B	5			I	12		
C	6			H	11		
D	7			G	10		
E	8			F	9		
P	25			O	24		
Q	26			N	23		
R	27			M	22		
S	28			L	21		
T	29			K	20		
	30				19		
	31				18		
	32				17		

DIAGNOSTIC SUMMARY

Plaque Score: A B C D F

Prior Score:

Behavior:

Fluoride Status:

Eruption sequence:

Brushing / Flossing:

Occlusion:

Habits:

Periodontal:

Caries:

Periodontal Screening & Recording: _____|_____|_____

Caries Risk Assessment: ☐Low ☐Moderate ☐High

TREATMENT PROPOSED

Upper Right **Upper Left**

Lower Right **Lower Left**

Treatment sequence, additional notations:

1.

2.

3.

4.

5.

Instructions given:

Assistant **Resident** **Faculty Instructor**

Figure 1-2, cont'd

Figure 1-3 Evidence of head lice infestation. Usually the insects are not seen, but their eggs or nits cling to hair filaments until they hatch. (Courtesy Dr. Hala Henderson.)

Figure 1-4 Lesion on the forehead above the left eyebrow is caused by ringworm infection. Several fungal species may cause lesions on various areas of the body. The dentist may identify lesions on the head, face, or neck of a patient during a routine clinical examination. (Courtesy Dr. Hala Henderson.)

obvious carious lesions. Although controlling carious lesions is important, the dentist should first evaluate the condition of the oral soft tissues and the status of the developing occlusion. If the soft tissues and the occlusion are not observed early in the examination, the dentist may become so engrossed in charting carious lesions and in planning for their restoration that other important anomalies in the mouth are overlooked. In addition, any unusual breath odors and abnormal quantity or consistency of saliva should also be noted.

The buccal tissues, lips, floor of the mouth, palate, and gingivae should be carefully inspected and palpated (Fig. 1-7). The use of the periodontal screening and recording program (PSR) is often a helpful adjunct when working with children. PSR is designed to facilitate early detection of periodontal diseases with a simplified probing technique and minimal documentation. Clerehugh and Tugnait[7] recommend initiation of periodontal screening in children following eruption of the permanent incisors and the first molars. They suggest routine screening in these children at the child's first appointment and at regular recare appointments so that periodontal problems are detected early and treated appropriately. Immunodeficient children are especially vulnerable to early loss of bone support.

A more detailed periodontal evaluation is occasionally indicated, even in young children. Periodontal disorders of children are discussed further in Chapter 14.

The tongue and oropharynx should be closely inspected. Enlarged tonsils accompanied by purulent exudate may be the initial sign of a streptococcal infection, which can lead to rheumatic fever. When streptococcal throat infection is suspected, immediate referral to the child's physician is indicated. In some cases it may be helpful to the physician and convenient for the dentist to obtain a throat culture specimen while the child is still in the dental office, which contributes to an earlier definitive diagnosis of the infection. The diagnosis and treatment of soft tissue problems are discussed throughout this book (see Chapters 3, 27, and 28.)

After thoroughly examining the oral soft tissues, the dentist should inspect the occlusion and note any dental or skeletal irregularities. The dentition and resulting occlusion may undergo considerable change during childhood and early adolescence. This dynamic developmental process occurs in all three planes of space, and with periodic evaluation the dentist can intercept and favorably influence undesirable changes. The patient's facial profile and symmetry; molar, canine, and anterior segment relationships; dental midlines; and relation of arch length to tooth mass should be routinely monitored in the clinical examination. More detailed evaluation and analysis are indicated when significant discrepancies are found during critical stages of growth and development. Diagnostic casts and cephalometric analyses may be indicated relatively early in the mixed-dentition stage and sometimes in the primary dentition. Detailed discussions of analyses of developing occlusions and interceptive treatment recommendations are presented in Chapters 20, 21, and 22.

Finally, the teeth should be inspected carefully for evidence of carious lesions and hereditary or acquired

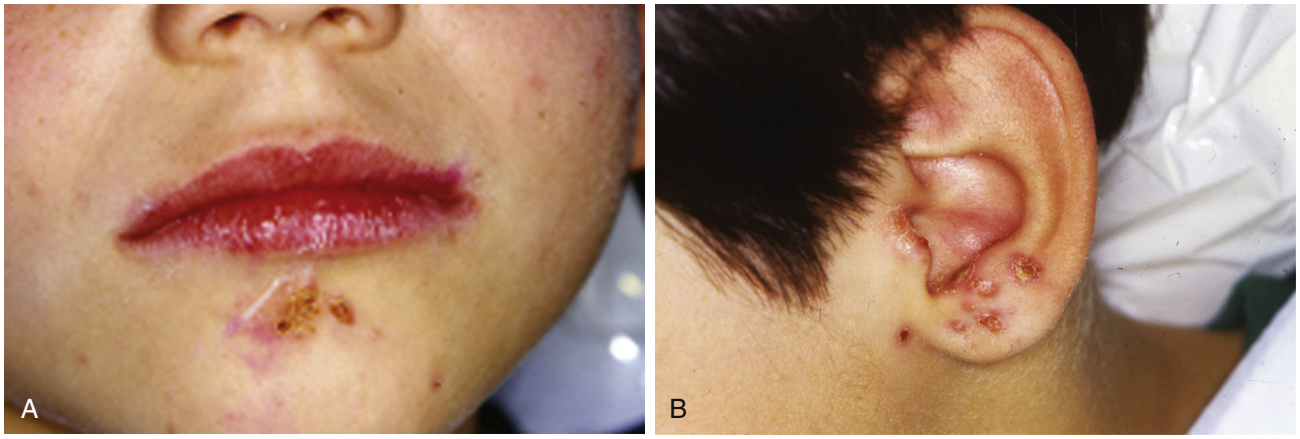

Figure 1-5 Characteristic lesions of impetigo on the lower face **(A)** and on the right ear **(B).** These lesions occur on various skin surfaces, but the dentist is most likely to encounter them on upper body areas. The infections are of bacterial (usually streptococcal) origin and generally require antibiotic therapy for control. The child often spreads the infection by scratching the lesions. (Courtesy Dr. Hala Henderson.)

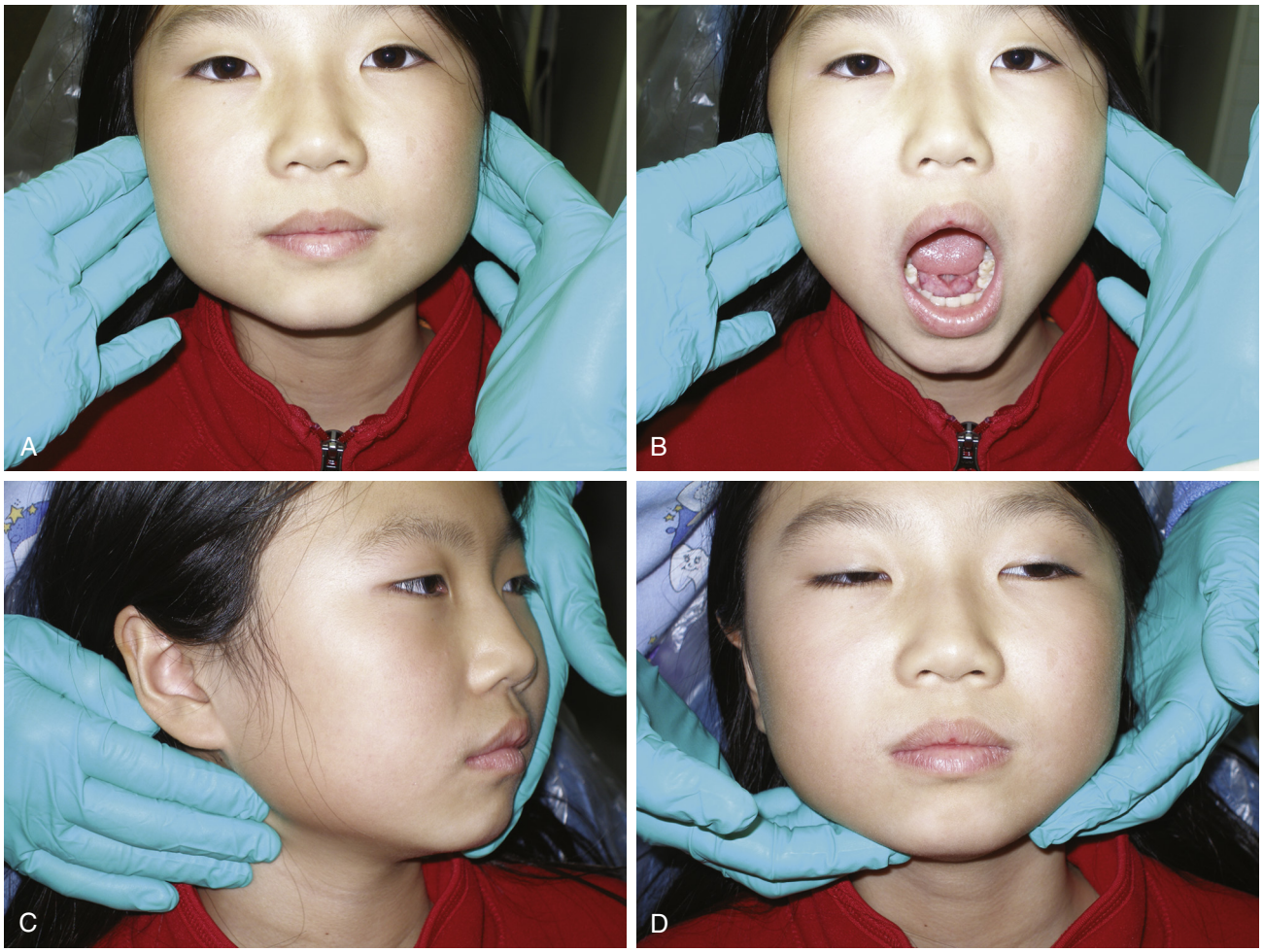

Figure 1-6 **A** and **B,** Observation and palpation of temporomandibular joint function. **C** and **D,** Palpation of the neck and submandibular areas.

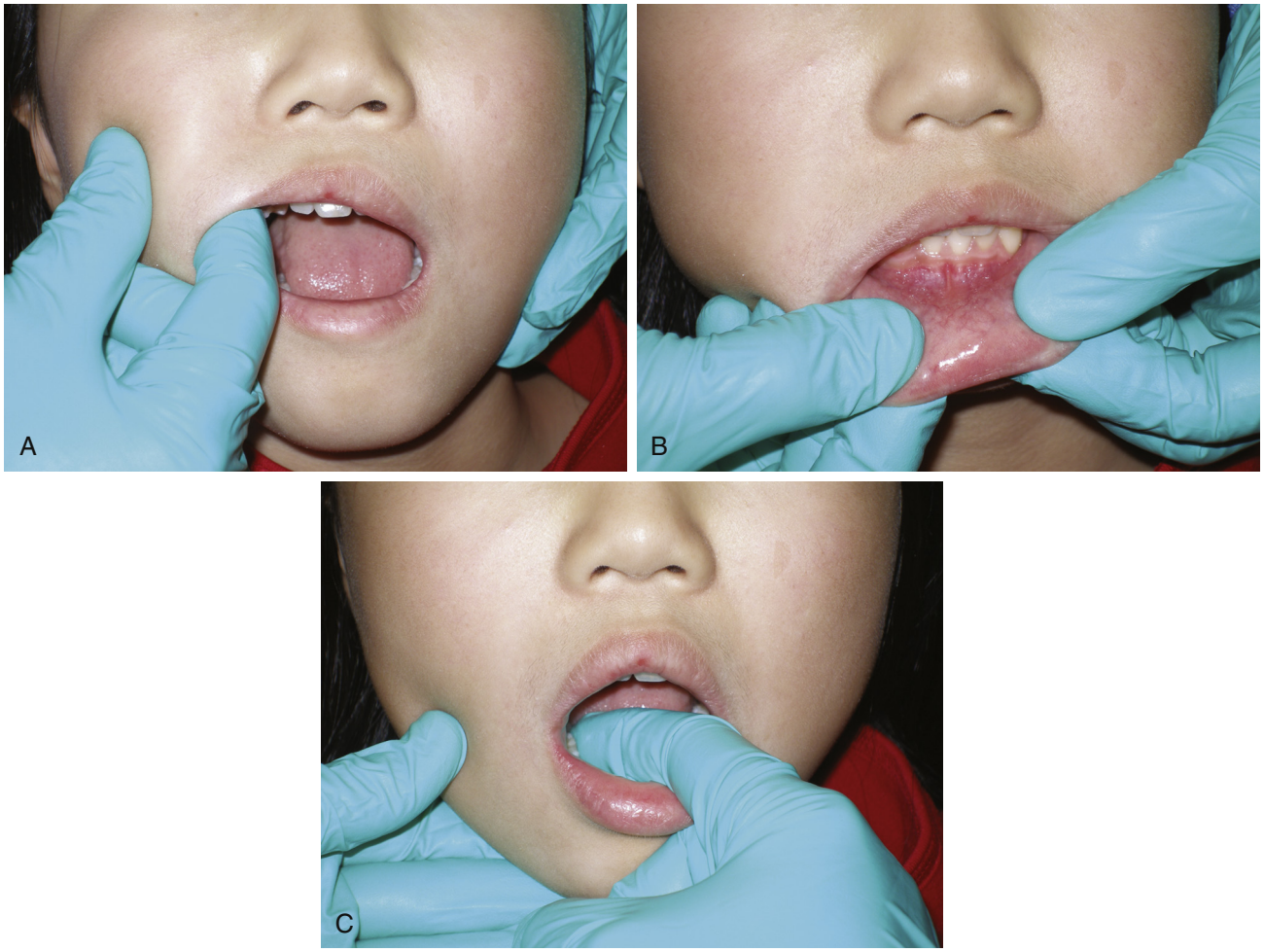

Figure 1-7 Inspection and palpation of the buccal tissues **(A),** the lips **(B),** and the floor of the mouth **(C).**

anomalies. The teeth should also be counted and identified individually to ensure that supernumerary or missing teeth are recognized. Identification of caries lesions is important in patients of all ages but is especially critical in young patients because the lesions may progress rapidly in early childhood if not controlled. Eliminating the etiology of the caries activity, preventive management of the caries process, and restoration of cavitated lesions will prevent pain and the spread of infection and will contribute to the stability of the developing occlusion.

Since it is preferable for the dentist to perform the clinical examination of a new pediatric patient before the radiographic and prophylaxis procedures, it may be necessary to correlate radiographic findings or other initially questionable findings with the findings of a second brief oral examination. This is especially true when the new patient has poor oral hygiene. Detailed inspection and exploration of the teeth and soft tissues cannot be performed adequately until the mouth is free of extraneous debris.

During the clinical examination for carious lesions, each tooth should be dried individually and inspected under a good light. A definite routine for the examination should be established. For example, a dentist may always start in the upper right quadrant, work around the maxillary arch, move down to the lower left quadrant, and end the examination in the lower right quadrant. Morphologic defects and incomplete coalescence of enamel at the bases of pits and fissures in molar teeth can often be detected readily by visual and explorer examination after the teeth have been cleaned and dried. The decision whether to place a sealant or to restore a defect depends on the patient's history of dental caries, the parents' or patient's acceptance of a comprehensive preventive dentistry program (including dietary and oral hygiene control), and the patient's dependability in returning for recare appointments.

In patients with severe dental caries, caries activity tests and diet analysis may contribute to the diagnostic process by helping define specific etiologic factors. These procedures probably have an even greater value in helping the patient and/or parents understand the caries disease process and in motivating them to make the behavioral changes needed to control the disease. The information provided to them should include instruction in plaque control and the appropriate recommendations for fluoride exposure. Dental caries susceptibility, the caries disease process, caries activity tests, diet analysis, and

caries control are discussed in Chapter 9. Plaque control procedures and instructions are detailed in Chapter 7.

The dentist's comprehensive diagnosis depends on the completion of numerous procedures but requires a thorough, systematic, and critical clinical examination. Any deviation from the expected or desired size, shape, color, and consistency of soft or hard tissues should be described in detail. The severity of associated problems and their causes must be clearly identified to the patient or parents before a comprehensive oral health care program can be expected to succeed.

During the initial examination and at subsequent appointments, the dentist and auxiliary staff members should be alert to signs and symptoms of child abuse and neglect. These problems are increasing in prevalence, and the dentist can play an important role in detecting their signs and symptoms; Chapter 6 is devoted to this subject.

UNIFORM DENTAL RECORDING

Many different tooth-charting systems are currently in use, including the universal system illustrated in the hard tissue examination section of Figure 1-2. This system of marking permanent teeth uses the numbers 1 to 32, beginning with the upper right third molar (No. 1) and progressing around the arch to the upper left third molar (No. 16), down to the lower left third molar (No. 17), and around the arch to the lower right third molar (No. 32). The primary teeth are identified in the universal system by the first 20 letters of the alphabet, A through T.

The Fédération Dentaire Internationale's Special Committee on Uniform Dental Recording has specified the following basic requirements for a tooth-charting system:

1. Simple to understand and teach
2. Easy to pronounce in conversation and dictation
3. Readily communicable in print and by wire
4. Easy to translate into computer input
5. Easily adaptable to standard charts used in general practice

The committee found that only one system, the two-digit system, seems to comply with these requirements. According to this system, the first digit indicates the quadrant and the second digit the type of tooth within the quadrant. Quadrants are allotted the digits 1 to 4 for the permanent teeth and 5 to 8 for the primary teeth in a clockwise sequence, starting at the upper right side; teeth within the same quadrant are allotted the digits 1 to 8 (primary teeth, 1 to 5) from the midline backward. The digits should be pronounced separately; thus the permanent canines are teeth one-three, two-three, three-three, and four-three.

In the "Treatment Proposed" section of the oral examination record (see Fig. 1-2), the individual teeth that require restorative procedures, endodontic therapy, or extraction are listed. Gingival areas requiring follow-up therapy are also noted. A checkmark can be placed beside each listed tooth and procedure as the treatment is completed. Additional notations concerning treatment procedures completed and the date are recorded on supplemental treatment record pages.

RADIOGRAPHIC EXAMINATION

When indicated, radiographic examination for children must be completed before a comprehensive oral health care plan can be developed, and subsequent radiographs are required periodically to enable detection of incipient caries lesions or other developing anomalies.

A child should be exposed to dental ionizing radiation only after the dentist has determined that radiography is necessary to make an adequate diagnosis for the individual child at the time of the appointment.

Obtaining isolated occlusal, periapical, or bite-wing films is sometimes indicated in very young children (even infants) because of trauma, toothache, suspected developmental disturbances, or proximal caries. It should be remembered that carious lesions appear smaller on radiographs than they actually are.

As early as 1967, Blayney and Hill[8] recognized the importance of diagnosing incipient proximal carious lesions with the appropriate use of radiographs. If the pediatric patient can be motivated to adopt a routine of good oral hygiene supported by competent supervision, many of these initial lesions can be arrested.

Radiographic techniques for the pediatric patient are described in detail in Chapter 2.

EARLY EXAMINATION

Historically, dental care for children has been designed primarily to prevent oral pain and infection, occurrence and progression of dental caries, premature loss of primary teeth, loss of arch length, and development of an association between fear and dental care. The dentist is responsible for guiding the child and parents, resolving oral disorders before they can affect health and dental alignment, and preventing oral disease. The goals of pediatric dental care are therefore primarily preventive. The dentist's opportunity to conduct an initial oral examination and parental consultation during the patient's infancy is a key element in achieving and maintaining these goals.

Some dentists, especially pediatric dentists, like to counsel expectant parents before their child is born. They consider it appropriate to discuss with expectant mothers the importance of good nutrition during pregnancy and practices that can influence the expected child's general and dental health.

It is also appropriate to inquire about medication that the expectant mother is taking. For example, prolonged ingestion of tetracyclines may result in discolored, pigmented, and even hypoplastic primary teeth.

The expectant mother should be encouraged to visit her dentist and to have all caries lesions restored. The presence of active dental caries and accompanying high levels of *Streptococcus mutans* can lead to transmission by the mother to the infant and may be responsible for the development of caries lesions at a very early age.

It is not intended that the pediatric dentist usurp the responsibility of the expectant mother's physician in recommending dietary practices; rather, the dentist should reinforce good nutritional recommendations provided by medical colleagues.

INFANT DENTAL CARE

The infant oral health care visit should be seen as the foundation on which a lifetime of preventive education and dental care can be built to help ensure optimal oral health into childhood. Oral examination, anticipatory guidance including preventive education, and appropriate therapeutic intervention for the infant can enhance the opportunity for a lifetime of freedom from preventable oral disease. The 2013 American Academy of Pediatric Dentistry guidelines on infant oral health care included the following recommendations:

1. All primary health care professionals who serve mothers and infants should provide parent/caregiver education on the etiology and prevention of early childhood caries (ECC).
2. The infectious and transmissible nature of bacteria that cause ECC and methods of oral health risk assessment (e.g., Caries Assessment Tool [CAT]), anticipatory guidance, and early intervention should be included in the curriculum of all medical, nursing, and allied health professional programs.
3. Every infant should receive an oral health risk assessment from his or her primary health care provider or qualified health care professional by 6 months of age.
4. Parents or caregivers should establish a dental home for infants by 12 months of age.
5. Health care professionals and all stakeholders in children's health should support the identification of a dental home for all infants at 12 months of age.

Thus it is appropriate for a dentist to perform an oral examination for an infant of any age, even a newborn, and an examination is recommended anytime the parent or physician calls with questions concerning the appearance of an infant's oral tissues. Even when there are no known problems, the child's first dental visit and oral examination should take place by at least 1 year of age. This early dental visit enables the dentist and parents to discuss ways to nurture excellent oral health before any serious problems have had an opportunity to develop. An adequate oral examination for an infant is generally simple and brief, but it may be the important first step toward a lifetime of excellent oral health.

Some dentists may prefer to "preside" during the entire first session with the infant and parents. Others may wish to delegate some of the educational aspects of the session to auxiliary members of the office staff and then conduct the examination and answer any unresolved questions. In either case, it is sometimes necessary to have an assistant available to help hold the child's attention so that the parents can concentrate on the important information being provided.

It is not always necessary to conduct the infant oral examination in the dental operatory, but it should take place where there is adequate light for a visual examination. The dentist may find it convenient to conduct the examination in the private consultation room during the initial meeting with the child and parents. The examination procedures may include only direct observation and digital palpation. However, if primary molars have erupted or if hand instruments may be needed, the examination should be performed in an area where instrument transfers between the dental assistant and the dentist can proceed smoothly.

The parents should be informed before the examination that it will be necessary to restrain the child gently and that it is normal for the child to cry during the procedure. The infant is held on the lap of a parent, usually the mother. This direct involvement of the parent provides emotional support to the child and allows the parent to help restrain the child. Both parents may participate or at least be present during the examination.

The dentist should make a brief attempt to get acquainted with the infant and to project warmth and caring. However, many infants and toddlers are not particularly interested in developing new friendships with strangers, and the dentist should not be discouraged if the infant shuns the friendly approach. Even if the child chooses to resist (which is common and normal), only negligible extra effort is necessary to perform the examination procedure. The dentist should not be flustered by the crying and resistant behavior and should proceed unhurriedly but efficiently with the examination. The dentist's voice should remain unstrained and pleasant during the examination. The dentist's behavior should reassure the child and alleviate the parents' anxiety concerning this first dental procedure.

One method of performing the examination in a private consultation area is illustrated in Figure 1-8, *A*. The dentist and the parent are seated face to face with their knees touching. Their upper legs form the "examination table" for the child. The child's legs straddle the parent's body, which allows the parent to restrain the child's legs and hands (Video 1-1: Examination of the mouth). An assistant is present to record the dentist's examination findings as they are dictated and to help restrain the child if needed. If adequate space is available in the consultation area, the approach illustrated in Figure 1-8, *B*, may be useful. The dental assistant is seated at a desk or writing stand near the child's feet. The dental assistant and the parent are facing the same direction, side by side and at a right angle to the direction that the dentist is facing. The dental assistant is in a good position to hear and record the dentist's findings as they are dictated, even if the child is crying loudly. These positions (see Fig. 1-8) are also convenient for demonstrating oral hygiene procedures to the parents.

The positions of the dentist, parent, child, and dental assistant during the examination at the dental chair are illustrated in Figure 1-9. The dental assistant is seated higher to permit good visibility and to better anticipate the dentist's needs. The assistant is also in a good position to hear and record the dentist's findings. The parent and the dental assistant restrain the child's arms and legs. The child's head is positioned in the bend of the parent's arm. The dentist establishes a chairside position so that not only the dentist's hands but also the lower arms and abdomen may be available for support of the child's head, if necessary.

The infant oral examination may often be performed by careful direct observation and digital palpation. The dentist may need only good lighting for visibility and gauze for drying or debriding tissues. Sometimes a tongue depressor and a soft-bristled toothbrush are useful. At other times, as previously mentioned, the dentist will want the complete

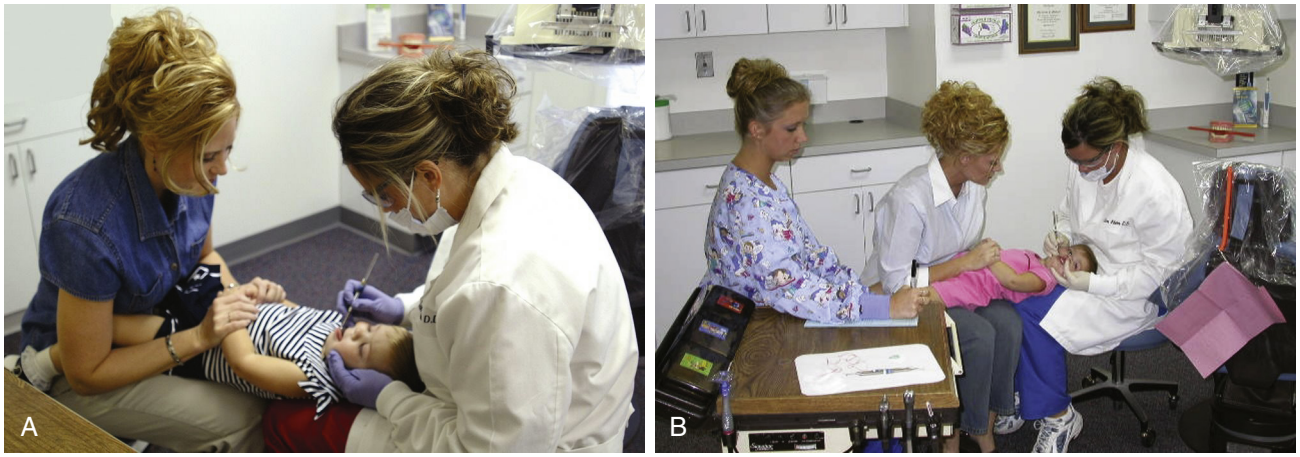

Figure 1-8 **A,** One method of positioning a child for an oral examination in a small, private consultation area. The dental assistant is nearby to record findings. **B,** If space allows three people to sit in a row, this method may make it easier for the dental assistant to hear the findings dictated by the dentist. The dental assistant also helps restrain the child's legs.

Figure 1-9 Oral examination of a very young child in the dental operatory.

operatory available. The examination should begin with a systematic and gentle digital exploration of the soft tissues without any instruments. The child may find this gentle palpation soothing, especially when alveolar ridges in teething areas are massaged. The digital examination may help relax the child and encourage less resistance. If hand instruments are needed, the dentist must be sure to have a stable finger rest before inserting an instrument into the child's mouth.

Although there is little effective communication between the dentist and patient, the child realizes at the conclusion of the examination that nothing "bad" happened and that the procedure was permitted by the parents, who were present and actually helped with the examination. The child will not hold a lasting grudge against anyone, and the experience will not have a detrimental effect on the child's future behavior as a dental patient. On the contrary, our experiences suggest that such early examinations followed by regular recall examinations often contribute to the youngsters' becoming excellent dental patients without fear at very young ages. These children's chances for enjoying excellent oral health throughout life are thus enhanced.

DETECTION OF SUBSTANCE ABUSE

It is within the scope of pediatric dentistry to be concerned with life-threatening habits and illnesses such as alcoholism and drug addiction, which may occur in the older child.

Rosenbaum[9,10] has reported that abusers in the teen years and younger are as common as adult addicts. Drug abuse problems interact directly with the dental care of a patient. Obtaining and maintaining a satisfactory history are important. The office health questionnaire, as presented in this chapter, must be worded to allow the patient or parent to give some indication of a drug problem. It is often difficult to detect addiction from casual observation. Therefore input from the patient giving an indication of addiction is needed. At subsequent visits the dentist must also consider changes in the general health history as well as answers to specific questions.

It is also important to know if the patient is taking drugs at the time of the dental visit because there could be an interaction with drugs, such as nitrous oxide, administered at the dental office. If the patient is under the influence of an abused substance, dental treatment should be postponed until a time when the patient is not "high."

Symptoms of substance abuse may include depression, feelings of inadequacy, frustration, helplessness, immaturity, self-alienation, poor object relations, and major deficiencies in ego structure and functioning. Heavy drug users tend to have poor impulse control and frequently neglect hygiene in general and oral hygiene specifically. In addition, because a patient is taking drugs that affect normal thought processes, the pain from untreated dental conditions may be masked. This combination of factors results in a patient with very little dental interest who is practicing unsatisfactory prevention, leading to increased oral disease.

Identification of substance abusers is difficult, even for an experienced observer. There are specific clues, however. Abrupt changes in behavior are common, as are signs of depression and moodiness. Interest in the opposite sex often decreases. Without any apparent consumption of alcohol, a drug-addicted person can appear intoxicated.

There may be a desperate need for money, as well as loss of weight and appetite. The presence of scars along veins could indicate drug injection. Addicts frequently wear long-sleeved shirts, regardless of the weather, in an effort to cover identifying scars.

Fletcher and colleagues[11] state that the use of illegal drugs and volatile substances is common among young people in developed countries, such as the United States and the United Kingdom. In addition to presenting direct health risks, drug use is associated with accidental injury; self-harm; suicide; and other "problem" behaviors, such as alcohol misuse, unprotected sex, and antisocial behavior. Drug use at an early age is also associated with future use of particularly harmful drugs, such as heroin or cocaine. In turn, dependence on these drugs is associated with high rates of morbidity and mortality, social disadvantage, and crime. It is because of these health and social problems that reducing teenage drug use is a priority.

Their review of the literature, however, suggests that positive ethos and overall levels of strong school relationships and engagement are associated with lower rates of drug use; and that, at the individual level, negative behaviors and attitudes relating to school are also associated with drug use.

MacDonald[12] reports that experimentation is a normal adolescent learning tool, but when combined with normal adolescent curiosity and fearlessness, it may be dangerous. Tobacco smoking is an example of a common teenage experiment. In a study by the National Survey on Drug Use and Health, 12% of adolescents of 12 to 17 years of age had smoked one or more cigarettes in the preceding month; and of those who had never smoked, more than 22% were considered susceptible to start smoking.[13]

ETIOLOGIC FACTORS IN SUBSTANCE ABUSE

Drug abuse in young people can be traced to many causes, the most important of which is considered to be rebellion against parents and society. Other factors may include a need to forget the pressures of daily living, a desire for pleasure, and a need to conform to a group with which the young people want to be associated.[14] Through drugs, young people obtain a momentary feeling of independence and power because they have disobeyed the rules of their parents and society. The satisfaction gained through rebelling against parents can give adolescents a reinforcing motive for persisting in drug abuse.

Children of wealthy parents are increasingly recognized as a high-risk group for the development of such traits as narcissism, poor impulse control, poor tolerance of frustration, depression, and poor coping ability. Therefore it is not surprising that a large number of children within this group use drugs to cope with frustrations, boredom, anxiety, and depression.

In general, compared to youngsters who do not use drugs, drug users have been found to be less interested in formal education, less involved in organized activities such as athletics, and less likely to have well-defined goals. Adolescents who use drugs heavily have been described as manifesting more psychological problems than do nonusers. Significantly higher percentages of nonusers of drugs reported close relationships with their parents. Children involved in abusing drugs are more often found to have experienced the loss of a parent or to have parents who are divorced.

SPECIFIC SUBSTANCES AND FREQUENCY OF USE

Since 1975, the University of Michigan's Institute for Social Research, funded by the National Institute of Drug Abuse, has collected data on past month, past year, and lifetime drug use among 12th graders. It was expanded in 1991 to include 8th and 10th graders. The most recent report (http://www.monitoringthefuture.org//pubs/monographs/mtf-overview2013.pdf) says that in the late 20th century, young Americans reached extraordinarily high levels of illicit drug use. In 1975, the majority of young people (55%) had used an illicit drug by the time they left high school. This rose to 66% in 1981, but declined to 41% by 1992—the low point. After 1992, in what the report calls the "relapse phase" of the epidemic, the proportion rose considerably to 55% in 1999 and gradually declined to 47% in 2009 before rising slightly to 50% by 2013.

Suppose the dentist identifies a person who needs help. What can be done? Unless the dentist is exceptionally qualified to handle addiction problems, the answer is direct or indirect referral to a treatment center. If the person expresses a need, the dentist may directly inform that person or the parents about area agencies that provide assistance. However, addicts may react defensively, even with hostility, if a direct approach is used. As with any problem related to general or dental health, preventive efforts must begin with the young. Children at a very young age need to be helped to develop a positive self-image, a sense of self-worth, and a separate identity.

SUICIDAL TENDENCIES IN CHILDREN AND ADOLESCENTS

During the examination of the child, the pediatric dentist should be alert to signs and symptoms of suicidal tendencies. How prevalent is suicide in the young child and adolescent? According to the American Academy of Child and Adolescent Psychiatry (http://www.aacap.org), thousands of teenagers commit suicide each year. It is the sixth leading cause of death in 5- to 14-year-olds and the third leading cause in 15- to 24-year-olds. Suicidal tendencies follow a pattern and background that can be observed by the astute professional or parent. The following excerpt is from the *American Academy of Child and Adolescent Psychiatry*[15]:

> Teenagers experience strong feelings of stress, confusion, self-doubt, pressure to succeed, financial uncertainty, and other fears while growing up. For some teenagers, divorce, the formation of a new family with step-parents and step-siblings, or moving to a new community can be unsettling and can intensify self-doubts. For some teens, suicide may appear to be a solution to their problems and stress.

Depression and suicidal feelings are treatable mental disorders. The child or adolescent needs to have his or her illness recognized and diagnosed, and appropriate treatment plans developed. When parents are in doubt as to whether their child has a serious problem, a psychiatric examination can be helpful. Many of the signs

and symptoms of suicidal feelings are similar to those of depression.

Parents should be aware of the following signs from adolescents who may attempt suicide:

- Changes in eating and sleeping habits
- Withdrawal from friends, family, and regular activities
- Violent actions, rebellious behavior, or running away
- Drug and alcohol use
- Unusual neglect of personal appearance
- Marked personality change
- Persistent boredom, difficulty concentrating, or a decline in the quality of schoolwork
- Frequent complaints about physical symptoms, often related to emotions, such as stomachaches, headaches, or fatigue
- Loss of interest in pleasurable activities
- Not tolerating praise or rewards

A teenager who is planning to commit suicide may also exhibit the following signs:

- Complain of being a bad person or "feeling rotten" inside
- Give verbal hints with statements such as, "I won't be a problem for you much longer," "Nothing matters," "It's no use," and "I won't see you again."
- Put his or her affairs in order; for example, give away favorite possessions, clean his or her room, or throw away important belongings
- Become suddenly cheerful after a period of depression
- Have signs of psychosis (hallucinations or bizarre thoughts)

Children who say they want to kill themselves should not be ignored, and further expressions of concern and discussion with the child are important. In addition, assistance from a mental health professional should be actively sought. With appropriate counseling and family support, intervention can be successful.

It should be recognized that the pediatric dentist and the orthodontist are in a unique position to recognize early warning signs of adolescent suicide. Loochtan and Cole[16] surveyed 1000 practicing orthodontists and 54 department chairs of postdoctoral programs. Of those surveyed, 50% had at least one patient who had attempted suicide, and 25% had at least one young patient who actually did commit suicide.

INFECTION CONTROL IN THE DENTAL OFFICE

The dental team is exposed to a wide variety of microorganisms in the saliva and blood of their patients. These may include hepatitis B and C, herpes viruses, cytomegalovirus, measles virus, mumps virus, chickenpox virus, human immunodeficiency virus, *Mycobacterium tuberculosis*, streptococci, staphylococci, and other non–vaccine-preventable infections. Because it is impossible to identify all of those patients who may harbor dangerous microorganisms, it is necessary to use standard precautions and practice infection control procedures routinely to avoid spread of disease. The following infection control procedures as described by Miller and Palenik[17] are based on those recommended for dentistry by the Centers for Disease Control and Prevention (CDC) in the Public Health Service of the U.S. Department of Health and Human Services[18]:

- Always obtain (and update) a thorough medical history (as discussed previously in this chapter) and include questions about medications, current illnesses, hepatitis, unintentional weight loss, lymphadenopathy, oral soft tissue lesions, or other infections.
- Clean all reusable instruments in an ultrasonic cleaner or washer/disinfector, and minimize the amount of hand scrubbing. Wear heavy rubber gloves, mask, and protective clothing and eyewear to protect against puncture injuries and splashing.
- Sterilize all reusable instruments that penetrate or come into contact with oral tissues or that become contaminated with saliva or blood. Metal or heat-stable instruments should be sterilized in a steam autoclave, a dry heat oven, or an unsaturated chemical vapor sterilizer. Heat-sensitive items may require up to 10 hours' exposure time for sterilization in a liquid chemical agent approved by the U.S. Food and Drug Administration as a disinfectant/sterilant, followed by rinsing with sterile water. High-level disinfection may be accomplished by submersion in the disinfectant/sterilant chemical for the exposure time recommended on the product label, followed by rinsing with water.
- Monitoring of sterilization procedures should include a combination of process parameters, including mechanical, chemical, and biological. These parameters evaluate both the sterilizing conditions and the procedure's effectiveness. Biological monitoring must occur weekly.
- Dental instruments must be wrapped before sterilization. Unwrapped instruments have no shelf life and must be used immediately after being processed.
- Personal protective equipment (gloves, masks, protective eyewear, and clinical attire) should be worn when treating patients.
- Contamination of clinical contact surfaces with patient materials can occur by direct spray or spatter generated either during dental procedures or by contact with gloved hands. Barrier protection of surfaces and equipment can prevent contamination of clinical contact surfaces, but is particularly effective for those that are difficult to clean. Barriers include clear plastic wrap, bags, sheets, tubing, and plastic-backed paper or other materials impervious to moisture. If barriers are not used, cleaning and disinfection of surfaces between patients should involve use of an EPA-registered hospital disinfectant with a tuberculocidal claim (i.e., intermediate-level disinfectant).
- Hand hygiene (e.g., handwashing, hand antisepsis, or surgical hand antisepsis) substantially reduces potential pathogens on the hands. Evidence indicates that proper hand hygiene is the single most critical measure for reducing the risk of the transmission of organisms. For routine dental examinations and nonsurgical procedures, handwashing and hand antisepsis is achieved by using plain or antimicrobial soap and water. If the hands are not visibly soiled, an alcohol-based hand rub is adequate.
- Regulated medical waste is only a limited subset of waste, constituting 9% to 15% of total waste in hospitals

and 1% to 2% of total waste in dental offices. Regulated medical waste requires special storage, handling, neutralization, and disposal and is covered by federal, state, and local rules and regulations. Examples of regulated waste found in dental practice settings are solid waste soaked or saturated with blood or saliva (e.g., gauze saturated with blood after surgery), extracted teeth, surgically removed hard and soft tissues, and contaminated sharp items (e.g., needles, scalpel blades, and wires).

- Dental prostheses, appliances, and items used in their fabrication (e.g., impressions, occlusal rims, and bite registrations) are potential sources for cross-contamination and require handling in a manner that prevents exposure of both practitioners and patients.

BIOFILM

The goal of infection control in dentistry is to reduce or eliminate exposure of patients and dental team members to microorganisms. Potential pathogens can usually come from patients and practitioners. Another source, however, could be from the environment, such as via air or water.

Dental unit water lines contain relatively small amounts of water, much of which is in continuous contact with the inner surfaces of the tubing. The water is not in constant motion with extended dormant periods. Movement of water varies, with greatest flow being in the middle of the tubing. Dental unit water lines readily become colonized by a variety of microorganisms, including bacteria, viruses, and protozoa. Water entering dental units usually contains few microorganisms. However, water coming out of the unit is often highly contaminated. Proliferation of microorganisms occurs within biofilms that adhere to internal surfaces of dental unit water lines.

Current guidelines[19] for the proper treatment of dental unit water lines include the following:

1. Dental line water should contain <200 colony-forming units per mL (CFU/mL).
2. For surgical procedures, use sterile or saline water from a single-use source.
3. Start each day by purging all lines by flushing thoroughly with water.
4. Purge all air and water from high-speed handpieces for 20 to 30 seconds after each patient.
5. Consider separate reservoirs, chemical treatment protocols, and sterile water delivery systems.
6. Use antiretraction valves and terminal flush devices into the dental unit.
7. Drain the water lines at the end of the day.
8. Disinfect dental units attached to hospital main water supplies every 4 months with 500 ppm chlorinated water.

EMERGENCY DENTAL TREATMENT

A patient's initial dental appointment is often prompted by an emergency situation. The diagnostic procedures necessary for an emergency dental appointment were outlined in this chapter previously, but the emergency appointment tends to focus on and resolve a single problem or a single set of related problems rather than provide a comprehensive oral diagnosis and management plan. Once the emergency problem is under control, the dentist should offer comprehensive services to the patient or parents.

The remainder of this book presents information for dentists and dental students to augment their diagnostic and management skills in providing oral health care services to children and adolescents during both emergency and preplanned dental visits.

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CHAPTER 2

Radiographic Techniques

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CHAPTER OUTLINE

Wilhelm Conrad Roentgen's discovery of x-rays on November 8, 1895, initiated the first dental radiographs ever taken, by Otto Walkhoff in January 1896. A new era was born, and ever since, dental radiographs have proven their significant value in dental and maxillofacial diagnosis. For many years, two-dimensional intraoral radiography and extraoral radiography were the only radiographic options; but a little more than two decades ago, three-dimensional imaging in dentistry (cone beam computed tomography, CBCT) became much more readily available. In addition, other advanced imaging modalities, such as multi-slice computed tomography (MSCT), magnetic resonance imaging (MRI), and ultrasound imaging, are also available.

This chapter provides a general overview of the techniques currently used in pediatric dental and maxillofacial radiology and will provide a clear overview of the image receptors, specialized techniques, and the indications and justifications for exposing pediatric patients to ionizing radiation or other imaging modalities.

RADIATION SAFETY AND PROTECTION

THE BASICS OF RADIATION PROTECTION

The three basic principles of radiation protection are as follows:

The Justification Principle

This principle states that one should expose patients to ionizing radiation only if there is no other way to obtain the diagnostic information or if this exposure will positively influence the diagnosis, the treatment, and the patient's health. The principle requires that one should attempt to obtain previously taken images because these contain important information and may negate the need for new radiographs. Special needs patients and children may not always cope well with radiographic procedures. If the cooperation of the patient is unlikely to result in a good-quality image, one should refrain from exposing the patient to ionizing radiation.

The Limitation Principle

This principle states that one should always try to keep the radiation dose as low as reasonably achievable (ALARA). Current selection criteria will assist the clinician in addressing the principle of dose limitation.

The Optimization Principle

Optimization means that one should obtain the best quality images possible, with both previous principles in mind. This can, however, imply the use of a technique that exposes the patient to a higher radiation dose, which can be justified only if the technique offers the greatest benefit for the patient and his/her health outcome.

The purpose for adhering to the above three principles is that x-rays can impart energy to the matter they traverse; if that matter is living tissue, then some biological injury may occur. Although much information is available regarding high levels of radiation (e.g., from cancer radiation treatments and nuclear accidents) and subsequent damage, little is known about the effects of low-energy ionizing radiation (as used in diagnostic radiology and dentistry in particular) on biological systems. Our assumptions of damage are based on extrapolation of data from high to lower levels of radiation. Therefore, two models have been devised to explain these effects: the non-threshold (stochastic) and threshold models. The non-threshold model suggests that any dose of x-rays can cause biological damage, whereas the threshold model suggests

that no detrimental effects of ionizing radiation occur below a particular level or "threshold" of x-ray exposure. In 2012, White and Mallaya reported that until low-energy ionizing radiation is proven to be risk-free, dental health professionals should protect patients accordingly.

Dental health professionals must be concerned about any risk that the patient may encounter during therapy, with focus on three primary biological effects of low-level radiation: (1) carcinogenesis, (2) teratogenesis (malformations), and (3) mutagenesis. Carcinogenesis and malformations are responses of somatic tissues and, in most instances, are believed to have a threshold response (deterministic effect); that is, a certain amount of radiation is necessary before the response can be seen. Mutations may occur as a response of genetic tissue (gonads) to ionizing radiation and are believed to have no threshold (stochastic effects). In general, younger tissues and organs are more sensitive to ionizing radiation, with the sensitivity decreasing from the period before birth until maturity. Furthermore, far higher doses of radiation can be withstood by localized areas than by the whole body. The annual background radiation for individuals living in the United States is about 3600 microSieverts. It is estimated that, on average, about 20% of that amount results from medical and dental diagnostic imaging. Later in this chapter, radiation doses will be discussed from the perspective of this annual background radiation. This information is important when discussing the potential impact of diagnostic x-ray imaging exposure with patients and parents.

To facilitate the calculation of effective radiation doses from certain diagnostic exposures, the International Commission on Radiological Protection (ICRP) has provided tissue-weighting factors for human tissues (Table 2-1).

Table 2-1

The Tissue-Weighting Factors (WT) as Suggested by the International Commission (Higher WT Equals More Radiation Sensitivity) on Radiological Protection (ICRP, 2005)

Tissue	WT (2005)
Bone marrow	0.12
Breast	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Esophagus	0.05
Gonads	0.05
Liver	0.05
Thyroid	0.05
Bone surface	0.01
Brain	0.01
Kidneys	0.01
Salivary glands	0.01
Skin	0.01
Remaining tissues	0.10

Some tissues are more vulnerable and susceptible to the effects of ionizing radiation. Table 2-2 shows the estimated risks for the development of a fatal cancer from exposure to diagnostic radiation. It is clear that the use of certain imaging modalities must be well justified. Table 2-3 shows the multiplication factors per age category, highlighting children's increased sensitivity to x-rays.

PROTECTION OF THE DENTAL STAFF

The best method for protecting dental staff from ionizing radiation is the use of shielding. Solid walls (preferably with a lead glass window) are the best protection one can achieve. However, some offices lack such walls, and the

Table 2-2

Estimated Fatal Cancer Risks from Several Radiographic Examinations (Data from Ludlow et al., 2008, *JADA*)

X-Ray Diagnostic Investigation	Estimated Risk of a Fatal Cancer (adult)
Full-mouth x-rays with phosphor storage plates or F-speed analog film and rectangular collimation	2 in 1 million
Full-mouth x-rays with phosphor storage plates or F-speed analog film and circular collimation	9 in 1 million
Full-mouth x-rays with D-speed analog film and circular collimation	21 in 1 million
Two bitewing radiographs with phosphor storage plates or F-speed analog film and rectangular collimation	0.3 in 1 million
Dental panoramic radiograph (solid-state sensor)	0.8 to 1.3 in 1 million
Skull frontal radiograph (phosphor storage plate)	0.3 in 1 million
Lateral skull radiograph (phosphor storage plate)	0.3 in 1 million

Table 2-3

Multiplication Factors Per Age Category for the Estimated Risks of Developing a Fatal Cancer as a Result of Diagnostic Radiographs*

Age Category	Multiplication Factor
<10 years	× 3
10-20 years	× 2
20-30 years	× 1.5
30-50 years	× 0.5
50-80 years	× 0.3
>80 years	× 0

*Whaites E: *Essentials of dental radiography and radiology*, Edinburgh, Churchill Livingstone, 2007.

radiographer must maintain a safe distance from the x-ray source (Fig. 2-1). Once the x-ray machine is engaged, the patient is to be considered the source of radiation. The radiographer should stand either at 90° to or behind the radiation source; at least 6 feet (2 m) from the radiation source is safe. One should never stand in the path of the primary radiation beam or hold the image receptor or the wall-mounted x-ray machine. If, for whatever reason, insufficient distance is maintained, one should wear a lead apron with thyroid shielding and stand in the appropriate position relative to the radiation source. The 6-foot rule also applies to panoramic and cephalometric imaging.

For CBCT imaging, one should always stand behind a radioprotective barrier.

PROTECTION OF THE PATIENT

In addition to the three basic principles of radiation protection (justification, limitation, and optimization), one can apply the following additional techniques to reduce the radiation burden to the patient:

- Collimation of the x-ray beam
- Correct focus-to-skin distance
- Lead apron with thyroid collar
- More radiation-sensitive image receptors

The use of rectangular collimation limits the surface being irradiated to the size of the image receptor, reducing the radiation dose by about 50%, compared with that achieved with a 2.75-inch-diameter (6 cm) circular collimator (Fig. 2-2). Rectangular collimators are available from different vendors. They are either attached to the tube head or are included in the image receptor holding device. Rectangular collimation also decreases the amount of scatter in the patient's tissues, which in turn results in better image quality.

The focus-to-skin distance is the distance between the x-ray machine's anode (where x-rays are created) and the skin of the patient's cheek or lip. Ideally this should be a minimum of 8 inches (20 cm) to reduce the amount of low-energy x-radiation reaching the patient. Many manufacturers recess the x-ray tube to increase the focus-to-skin distance without increasing the overall length of the tube head.

The utility of a lead apron (as opposed to a thyroid collar) (Fig. 2-3) has been extensively discussed. ICRP guidelines suggest that the use of a lead apron is not necessary with rectangular collimation, short exposure times, adequate x-ray energies, and fast image receptors. Several studies have shown that, with rectangular collimation, the patient is afforded protection from scatter radiation similar to that achieved with a lead apron.

Fast image receptors, which require less exposure time, are advised, since their use will enable the lowest possible radiation dose to be absorbed by the patient. If direct exposure film is used, either E- or F-speed film is recommended. D-speed film requires at least twice the exposure of E-speed film and approximately 70% more exposure than F-speed film. Digital image receptors, either photostimulable phosphor plates (PSPPs) or solid-state sensors, require much less exposure than D-speed film. Thus, digital image receptors and E- or F-speed film are considered to achieve similar lower radiation doses for patients.

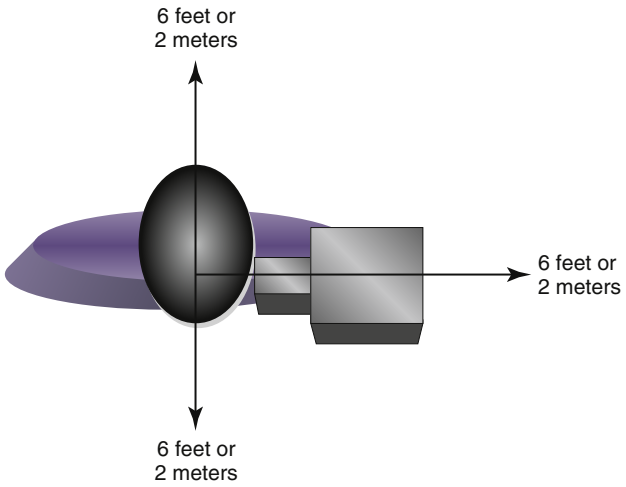

Figure 2-1 Safe locations for the radiographer when obtaining an intraoral radiograph. Bird's eye view of a patient being exposed for a bitewing radiograph. The arrows indicate the safest place for the radiographer to stand: at least 6 feet or 2 meters from the patient.

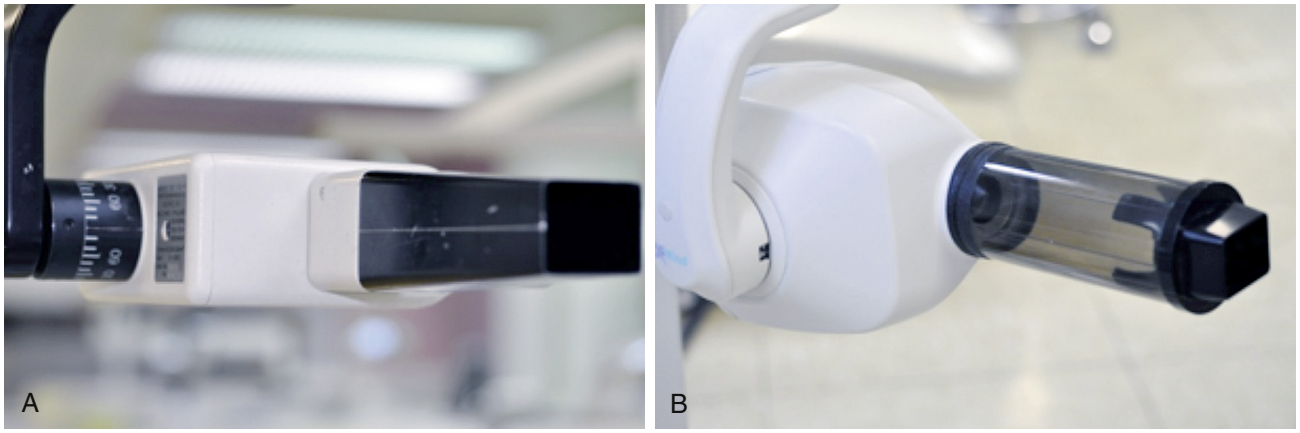

Figure 2-2 Examples of rectangular collimators. The rectangular end of the beam-indicating device decreases the exposed surface by more than 50%, compared with a 2.75-inch-diameter round collimation. The image on the left shows a non-removable rectangular collimator mounted on an intraoral x-ray machine. The image on the right shows a removable rectangular collimator (DENTSPLY® Universal Collimator) mounted on the circular open-ended beam-indicating device.

Figure 2-3 An apron containing lead or a material equivalent to lead for dental use.

When a lead apron is used with patients undergoing panoramic imaging, the apron must be placed high in the front, low in the back of the neck, and low over the shoulders. With correct positioning, the apron will not be captured in the panoramic images.

Correct positioning of the patient, image receptor, and tube head as well as appropriate exposure factors will decrease the need for retakes and will help keep the patient's dose as low as reasonably achievable. Darkroom quality assurance is essential if the radiographic imaging is film-based. Adequacy of safe lights, processing chemistry, and equipment maintenance and cleaning should be continuously monitored to maintain the quality and longevity of the film-based image.

From the above, it is clear that there are several actions one can take to minimize absorbed radiation doses and optimize image quality.

RADIOGRAPHIC IMAGE RECEPTORS

ANALOG FILM

Analog film is still used by almost 50% of clinicians in the United States. Some dental professionals have not yet switched to digital radiography or have made only a partial switch (e.g., film for intraoral radiographs and digital for panoramic).

Direct Film

Direct analog film is the film of choice for intraoral radiography. It is called direct because of its high sensitivity to x-rays. Only E- or F-speed film should be used because these require shorter radiation exposure times and hence contribute to a lower radiation burden for the patient. The exposure times needed for E- and F-films are comparable with those for digital image receptors. Direct analog film comes in different sizes (Table 2-4), making it suitable for different patients and tasks. The smallest size is 22 × 35 mm (ISO format 0), which can be used for bitewing radiographs in the primary dentition and for periapical images of individual maxillary or mandibular incisors. Such film is often called "pedo-size" or "child-size." The ISO format 1 size is 24 × 40 mm and can be used for the same purposes as described for size 0. The ISO format 2 size is 31 × 41 mm and is probably the most common size used. It can be used for bitewing images, periapical images in children in a transitional dentition, in adolescents and adults, as well as for occlusal radiographs in the primary dentition. The ISO format 3 size is 27 × 54 mm, which is used only for bitewing images in the transitional or permanent dentition. The largest size is 57 × 76 mm (ISO format 4), typically used for occlusal radiographs of the mandible or maxilla in the mixed and permanent dentition. Film packages contain either single or double film. Since analog film is single-use, packages can be bent if necessary, although this should be minimized to reduce the likelihood of image distortion. Disadvantages of analog film include double exposures and need for sufficient office space to store chemicals, processor, and radiographs.

Table **2-4**

ISO Formats (International Organization for Standardization) of Intraoral Analog Film and Phosphor Storage Plates and their Dimensions

ISO Format	Dimensions (mm)
0	22 × 35
1	24 × 40
2	21 × 41
3	27 × 54
4	57 × 76

Figure 2-4 An opened panoramic cassette (15 × 30 mm) with intensifying screens on both sides (white surfaces) and analog film (blue-purple). A similar cassette, but without intensifying screens, is used for phosphor storage plates.

Indirect Film

Indirect analog film is more sensitive to light than it is to x-rays and should be used only in a cassette with an intensifying screen (Fig. 2-4). Indirect film is usually 15 × 30 cm or

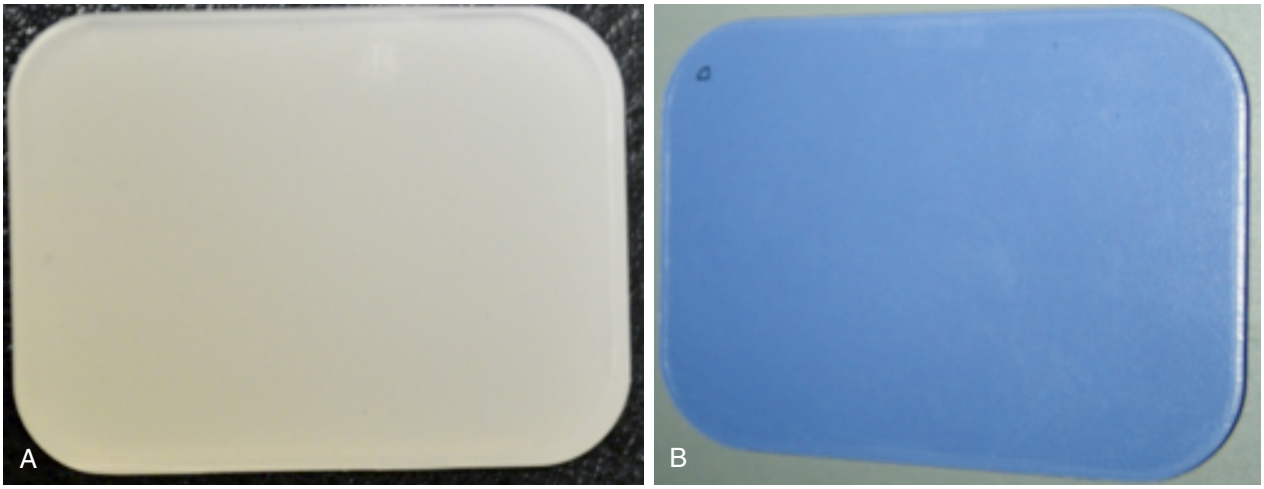

Figure 2-5 The physical appearance of a phosphor storage plate (left) looks very similar to that of analog film (right). The ISO format 2 is shown here.

18 × 24 cm, depending on its application. The intensifying screen converts the x-ray energy into light, which reaches the film and forms the latent image. In dentistry, this type of film is used in panoramic imaging and cephalometric radiography. The use of intensifying screens in cassettes keeps the exposure time as short as possible, but the images are less sharp than those obtained with direct analog film. The cassette should be checked regularly for light-tightness to ensure that no light can cause fogging of the film. The intensifying screens should be kept clean since dust or other particles can cause radiopaque artifacts in the image. One should use only the manufacturer's recommended cleansing agent to clean the intensifying screens.

PHOTO-STIMULABLE PHOSPHOR STORAGE PLATES

PSPPs (Fig. 2-5) appear very similar to analog film and also come in different sizes. This technique is also referred to as indirect digital imaging because the image is captured in an analog format and converted to a digital image when scanned and is not displayed immediately when the radiographic image is captured. The phosphor layer is comprised of europium-activated barium fluorohalide which, when exposed to x-rays, will capture a latent image. The phosphor plate emits a blue fluorescent light when exposed to a red helium laser light inside the PSPP scanner. The blue emissions captured by a photomultiplier are subsequently converted into a visible image. Once the image is generated, the scanner will expose PSPPs to white light to erase the latent image. Because PSPPs are sensitive to white light, the scanner cannot be placed in a brightly lit area, since this will degrade the image once the phosphor plates are freed from the light-tight barrier. PSPPs come in different sizes and can be used for either intraoral or extraoral applications. When used for intraoral radiography, they should be wrapped in a single-use plastic light-tight barrier to avoid both cross-contamination and the toxicity of the phosphor layer. When PSPP is used in a cassette for extraoral radiography, there is no need for it to be wrapped in a plastic barrier. The cassette, however, should be light-tight and should not contain intensifying screens, as is the case with analog indirect film. Because of the various sizes and flexibility of PSPPs, it is acceptable for intraoral radiography in pediatric patients and patients with special needs. The biggest disadvantage of PSPPs is their susceptibility to scratches, bite marks, and creasing, which could damage the phosphor layer (Fig. 2-6). This damage is irreversible and will always be visible as a radiopacity in the image. Just as with analog film, double exposures are possible with this technology.

SOLID-STATE SENSORS

Solid-state sensors (Fig. 2-7) are also known as direct digital receptors because they display the radiographic image instantaneously following exposure. There are two different types of solid-state sensors: charged coupled devices (CCD) and complementary metal oxide semiconductors (CMOS). These sensors differ in how the image is captured but appear similar in both external appearance and image output. Both CCD and CMOS sensors use a scintillation screen (usually gadolinium oxysulfide or cesium iodide) to transform the x-ray energy into visible green light, which is then converted into a visible image. Direct digital sensors are available in sizes 0, 1, and 2. The primary disadvantage of these sensors is that they are relatively bulky and not always easy to position in the patient's mouth (Video 2-1: Sensor placement: use of direct digital radiology technique in the operating room). The majority of direct digital sensors are attached to a computer by a shielded wire cable, which can be damaged by repeated biting. The solid-state sensors are also incorporated into extraoral radiography devices, such as panoramic machines and cephalometric units. The sensors are arranged in a vertical array and capture the x-rays while the panoramic or cephalometric machine scans. The image is formed by vertical lines or columns of pixels. Some manufacturers use a lens in front of the solid-state sensor so that the image from a cephalometric unit can be obtained in one exposure, instead of via a scanning motion from anterior to posterior. This saves time and radiation dose and helps reduce motion artifacts.

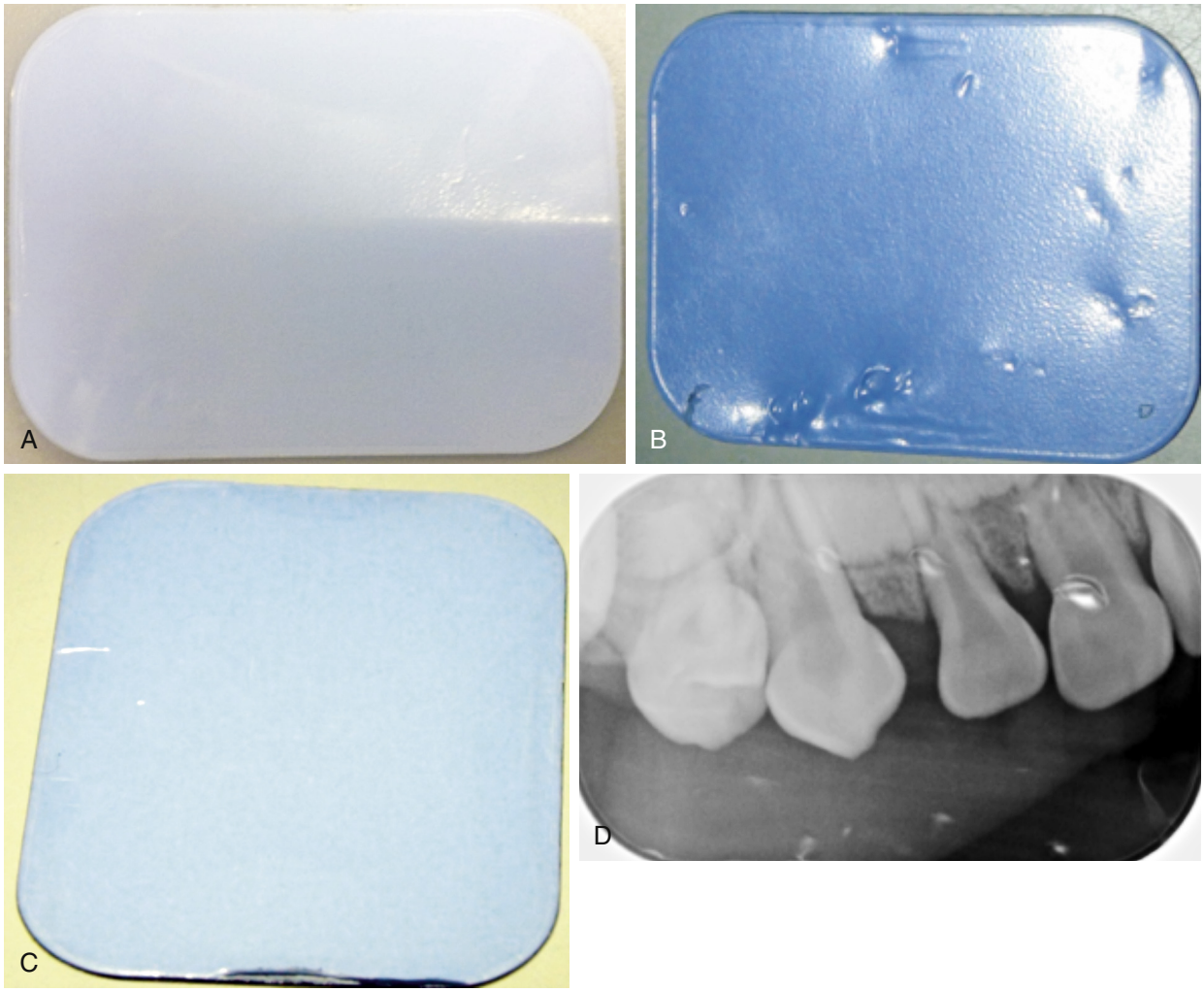

Figure 2-6 **A,** Phosphor plate that has been bent. **B,** Phosphor plate that has been bitten. **C,** Phosphor plate with curling of the phosphor layer on the edge of the short side of the plate. **D,** Phosphor plate image taken with a phosphor plate ISO format 0, with several bitemarks and scratches. The latter will appear on every image that will be taken with this phosphor storage plate.

Figure 2-7 Solid-state sensors, sizes 0, 1, and 2. (Courtesy SIRONA DENTAL SYSTEMS, INC.)

IMAGE-VIEWING CONDITIONS

Analog film should be viewed on a clean and bright view box, with a clean viewing surface and a properly functioning light source. Optimal viewing conditions should allow one to collimate the light, so the light area is restricted to the size of the film. The viewer's eyes should be blocked to surrounding light to ameliorate perception of details. Also, the ambient light in the room should be dimmed so that more details in the radiographic image can be seen. This is not always feasible in a dental office setting, but efforts should be made to place the view box in a dimmed area of the office.

Digital images are viewed on a computer monitor or screen. Ideally, ambient light should be subdued and the monitor calibrated. Some viewing software programs allow for calibration of the computer screen. If they do not, a "monitor calibration screen" can easily be downloaded from the Internet (Fig. 2-8). Monitor performance should be evaluated periodically. The monitor

Figure 2-8 Example of monitor calibration screens.

should be positioned in an area of subdued lighting away from a window or bright light. Touch-screen monitors should not be used since fingerprints can cause image quality to deteriorate. From the literature, it is clear that most computer monitors provide sufficient resolution and contrast for the vast majority of dental diagnostic needs.

A wide range of image receptors can be used in pediatric and special-needs dentistry. It is up to the dental professional to choose the system that works best in his or her practice since technology changes rapidly and image receptors will also change. Perhaps in the near future, technology will be available that makes image capture easier for both the clinician and the patient. Digital image receptors offer the opportunity for the captured image to be enhanced. Common enhancements include density and contrast, magnification, and edge-sharpening. Figure 2-9 demonstrates the effects of density and contrast enhancements.

RADIOGRAPHIC TECHNIQUES

Multiple radiographic techniques must be used to manage the wide range of pediatric and special-needs dental patients. The patient's size and ability to cooperate must be considered when a radiographic technique is selected.

INTRAORAL RADIOGRAPHY

Intraoral tube heads should generate between 60 and 70 kVp to produce adequate diagnostic images. The timer must be accurate to allow for short exposure times. Radiation-sensitive (rapid) image receptors should be used at all times.

Collimation of the radiation beam is advised to reduce the irradiated surface area to the size of the image receptor. There are several types of intraoral radiographs, each of which has specific indications and limitations.

Periapical Radiography

Periapical radiographs should show the crown of the tooth and at least 3 mm beyond the apex of the tooth. To achieve this coverage, one can use either the paralleling technique or the bisecting angle technique. The paralleling technique is preferred because of its accuracy.

Paralleling Technique. This is the most accurate technique for taking intraoral radiographs. The image receptor should be positioned parallel to the long axis of the teeth, while the x-ray beam is directed perpendicular to the image receptor. Ideally, image receptor holders that enable one to aim easily and correctly should be used (Fig. 2-10). This means that the aiming device must firmly grip the image receptor and that there is an extraoral component that allows the x-ray beam to be positioned correctly in both the vertical and horizontal planes. Other holders, such as those displayed in Figure 2-11, do not provide this extraoral component, and can produce either elongation or foreshortening of the image if the vertical angulation is incorrect or overlapping of proximal surfaces if the horizontal angulation is incorrect. Both angulation errors can result in the need for a retake.

Bisecting Angle Technique. In the bisecting angle technique, the image receptor is placed as close to the teeth as possible, and the central x-ray is directed perpendicular to a line that bisects the angle created by the tooth and image receptor (Fig. 2-12). This technique is obviously more prone to geometric errors and should not be regarded as the preferred technique. Elongation or foreshortening (vertical angulation errors) of the image or interproximal overlap (horizontal angulation errors) of the image is often the result of inaccurate aiming.

Bitewing Radiography

Bitewing radiographs are intended to assess interproximal caries and interproximal bone height. Bitewing geometry is based on the paralleling technique, where the image receptor is placed parallel to the teeth and the x-ray beam is aimed perpendicular to the receptor. Overlap of proximal surfaces is minimal with the proper image receptor holders, which assist in directing the x-ray beam through the proximal contacts. However, it is the clinician's evaluation of the receptor placement that determines the accuracy of the image, rather than

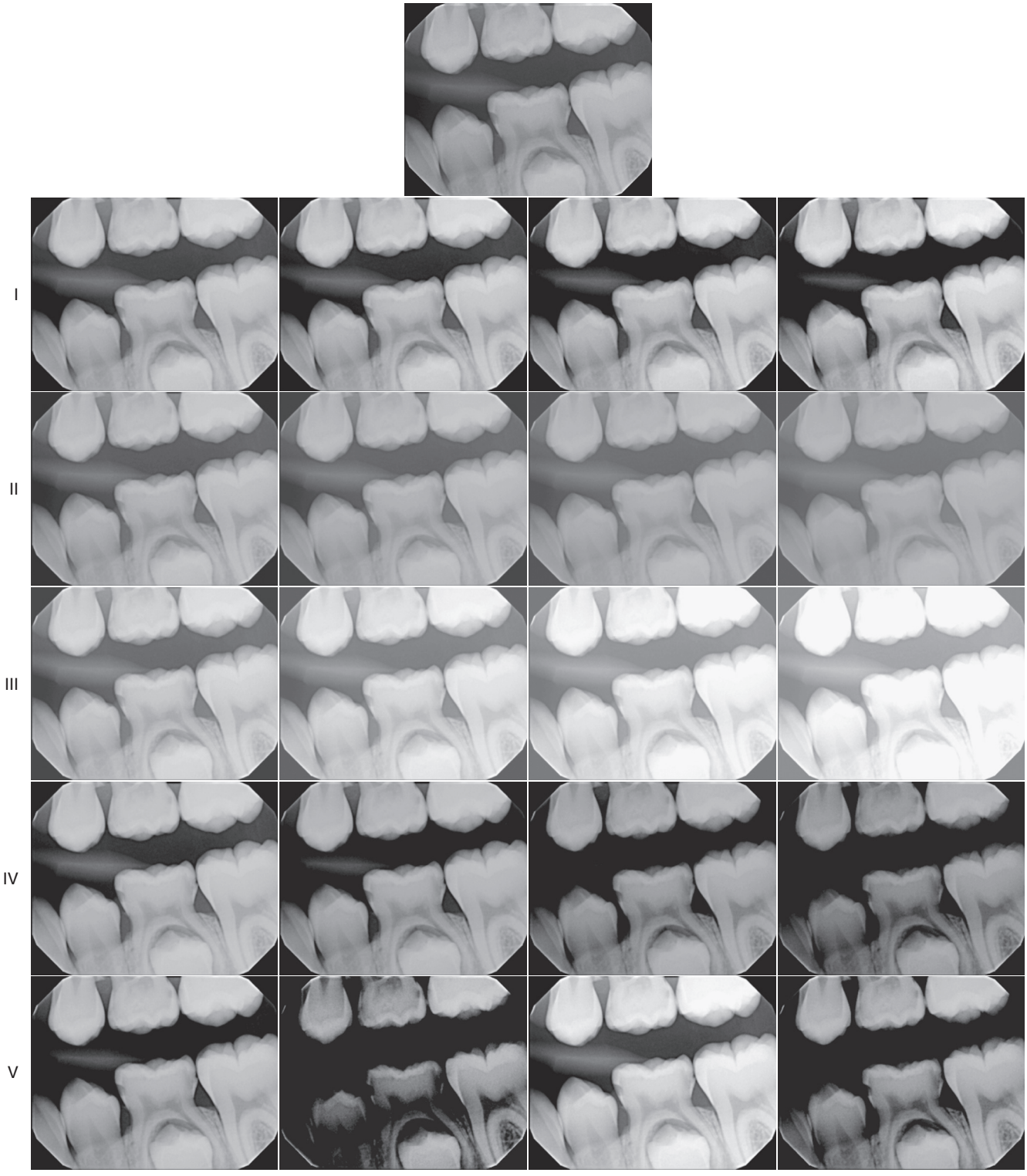

Figure 2-9 This figure shows how adjustments in contrast and density can alter the information in the image one sees on the screen. The image at the top is the original image displayed by the software. The images in the first line have increasing contrast, and those in the second line have decreasing contrast. The images in the third line have decreasing density, and those in the fourth line have increasing density. The bottom line is a combination of changed contrast and density.

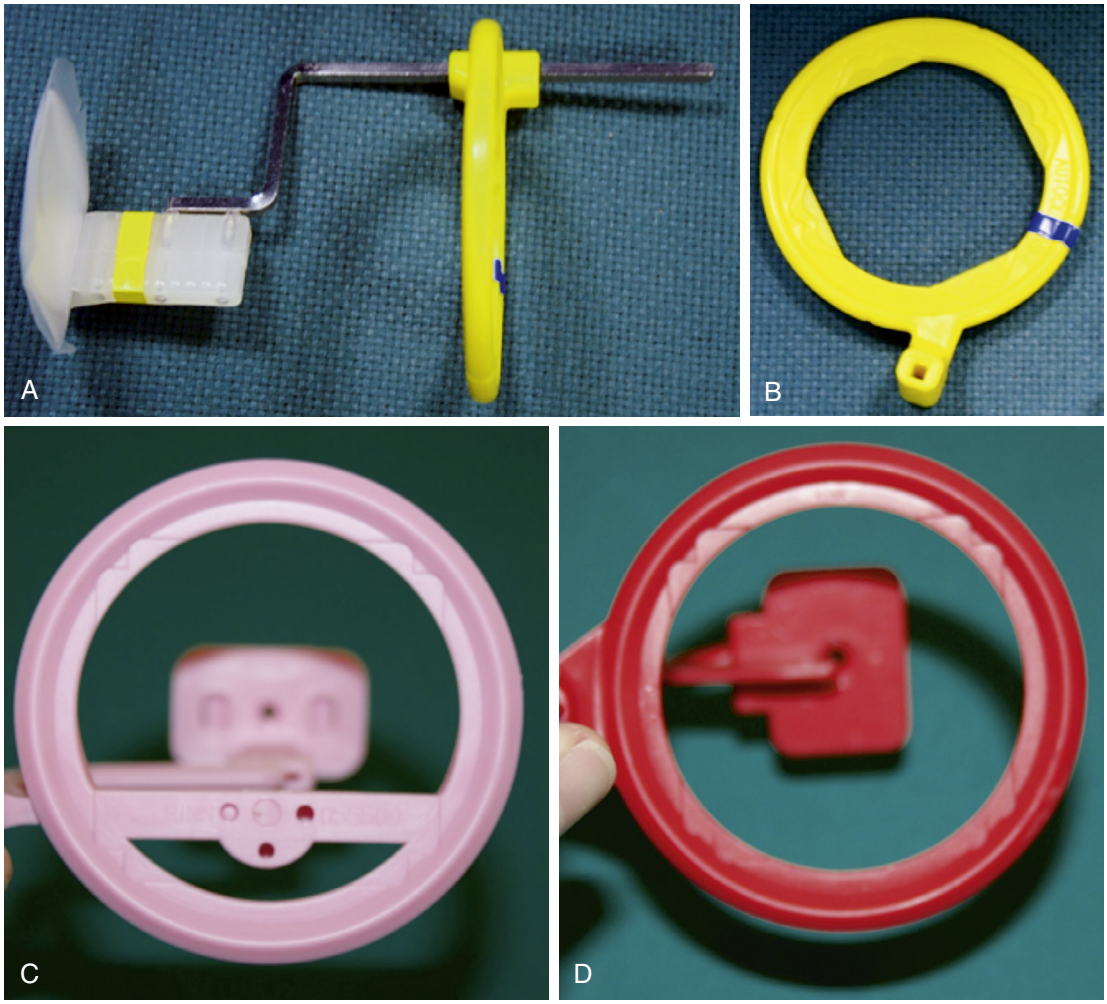

Figure 2-10 Illustration of the Rinn® paralleling technique beam-aiming and image receptor holding device. The bite block holds the image receptor firmly and allows for ideal positioning in the patient's mouth. It also allows for the attachment of a metal rod that aids in correct horizontal and vertical aiming of the x-ray beam. The plastic ring (yellow) demonstrates rectangular cut-outs that allow the rectangular collimator/beam-aiming device to be aimed perpendicular to the image receptor. The two images at the bottom are other examples of acceptable image receptor holders/aiming devices.

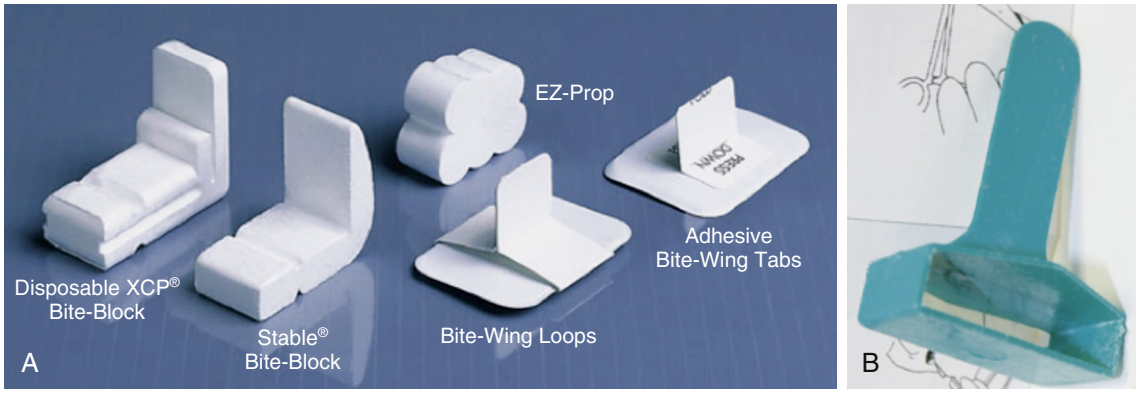

Figure 2-11 Image receptor holders without extraoral aids. It is obvious that these are not ideal for aiming perfectly perpendicular to the image receptor.

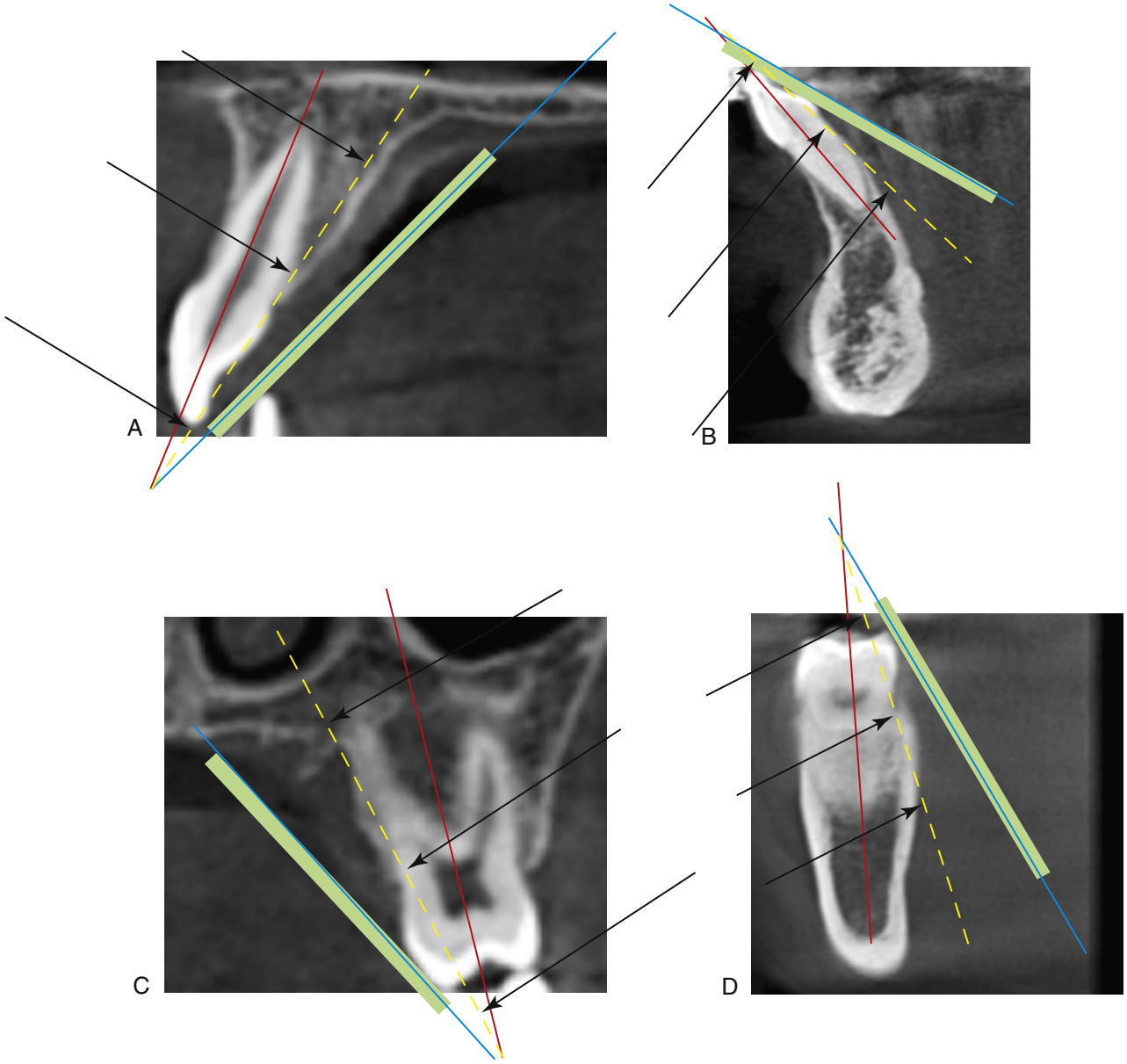

Figure 2-12 The bisecting angle technique illustrated for maxillary and mandibular incisors and for mandibular and maxillary molars. The x-ray beam (black arrows) must be aimed perpendicular to the imaginary bisecting angle (interrupted yellow line) between the long axis of the tooth (red line) and the long axis of the image receptor (blue line).

the receptor holder (Fig. 2-13). Paper tabs, styrofoam tabs, or a device like the Ezee Grip to hold the image receptor in the mouth does not offer extraoral guidance to aim the central x-ray through the proximal contacts.

Anterior Maxillary Occlusal Technique. In the anterior maxillary occlusal technique, the patient's occlusal plane should be parallel to the floor, and the sagittal plane should be perpendicular to the floor (Fig. 2-14). A size 2 image receptor is placed in the patient's mouth so that the long axis of the film runs from left to right, rather than anteroposteriorly, and the midsagittal plane bisects the film. The patient is instructed to bite lightly to hold the receptor; a tongue blade can be attached to PSPP or film receptors (Fig. 2-15), and rigid receptors should be wrapped in gauze to protect the sensor when the patient bites on it. The anterior edge of the receptor should extend approximately 2 mm in front of the incisal edge of the central incisors. The central x-ray is directed to the apices of the central incisors and a centimeter (half-inch) above the tip of the nose and through the midline. The vertical angle is +60°. This receptor is exposed at the usual setting for maxillary incisor periapical films.

Posterior Maxillary Occlusal Technique. In the posterior maxillary occlusal technique, the patient's occlusal plane should be parallel to the floor, and the sagittal plane should be perpendicular to the floor. A size 2 image receptor is placed in the patient's mouth so that the long axis of the film is parallel to the floor. The anterior edge of the receptor should extend just

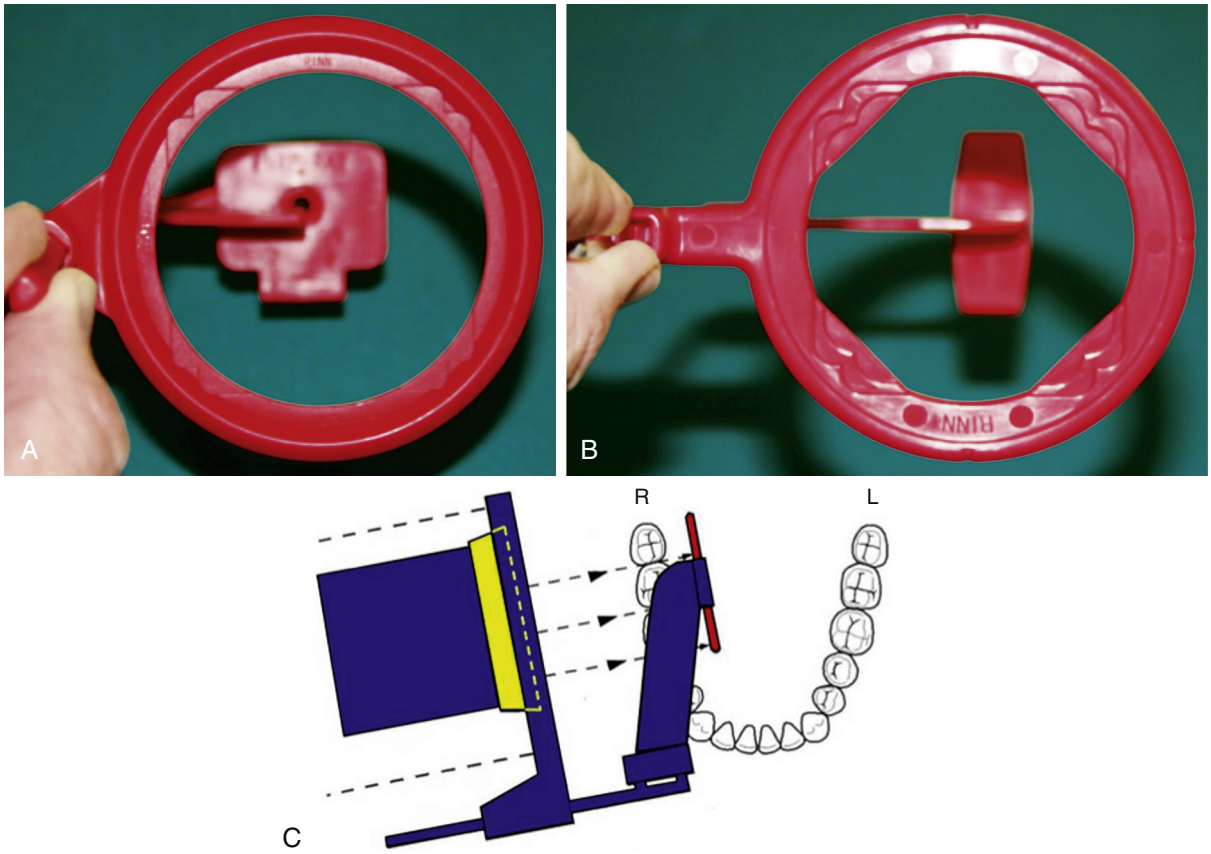

Figure 2-13 Bitewing holders with extraoral aids that allow for proper perpendicular aiming at the image receptor and the teeth. The bottom image represents a schematic view of how a bitewing image should be taken and how the image receptor holder aiming device (e.g., Rinn®) should be used.

mesial to the canine. The outer buccal edge of the receptor should extend approximately 2 mm beyond the primary molar crowns. The patient is instructed to bite lightly to hold the receptor. The central x-ray is directed toward the apices of the primary molars as well as interproximally. The vertical angle is +50°. The receptor is exposed at the usual setting for maxillary premolar periapical projection.

Anterior Mandibular Occlusal Technique. The film placement for the anterior mandibular occlusal technique is identical to that for the anterior maxillary occlusal technique, except that the receptor must be placed so that the tube side faces the x-ray source (Fig. 2-16). In addition, when the patient bites on the receptor, the anterior edge of the receptor is 2 mm beyond the incisal edge of the lower incisors. The patient's head is positioned so that the occlusal plane is at a 45° angle. The cone is then aligned at a –15° vertical angle, and the central x-ray is directed through the symphysis.

Oblique Occlusal Radiography

Oblique occlusal radiography is also based on the bisecting angle technique; it is a good alternative for patients with a severe gag reflex or who cannot tolerate the positioning of the image receptor holder device. It is advisable to tape two wooden tongue depressors around the image receptor to position it in the patient's mouth (see Fig. 2-15). Make sure that the long edge of the film or phosphor plate is visible 1 to 2 mm buccal to the teeth. Position the patient so that the occlusal plane is parallel to the floor. Aim the x-ray beam perpendicular to the bisecting line between the long axis of the tooth and the axis of the occlusal plane. For maxillary images, the patient faces forward. For mandibular images, the patient should turn the head to the opposite side to position the x-ray machine pointing upward, 45° to the mandibular teeth. If the patient faces forward, the tube head will be blocked by the patient's shoulders. The result of these projections should provide a periapical view of the posterior teeth (Fig. 2-17). It is obvious that errors in the vertical or horizontal plane can easily be made, and that foreshortening or elongation and/or overlapping of proximal surfaces can easily occur.

Localization Techniques

One method of localizing embedded or unerupted teeth involves the buccal object rule (also referred to as the parallax technique or the "same lingual opposite buccal" [SLOB] rule), which states that the image of any buccally oriented object appears to move in the opposite direction from a moving x-ray source. Conversely, the image of any lingually oriented object appears to move in the same direction as a moving x-ray source (Fig. 2-18).

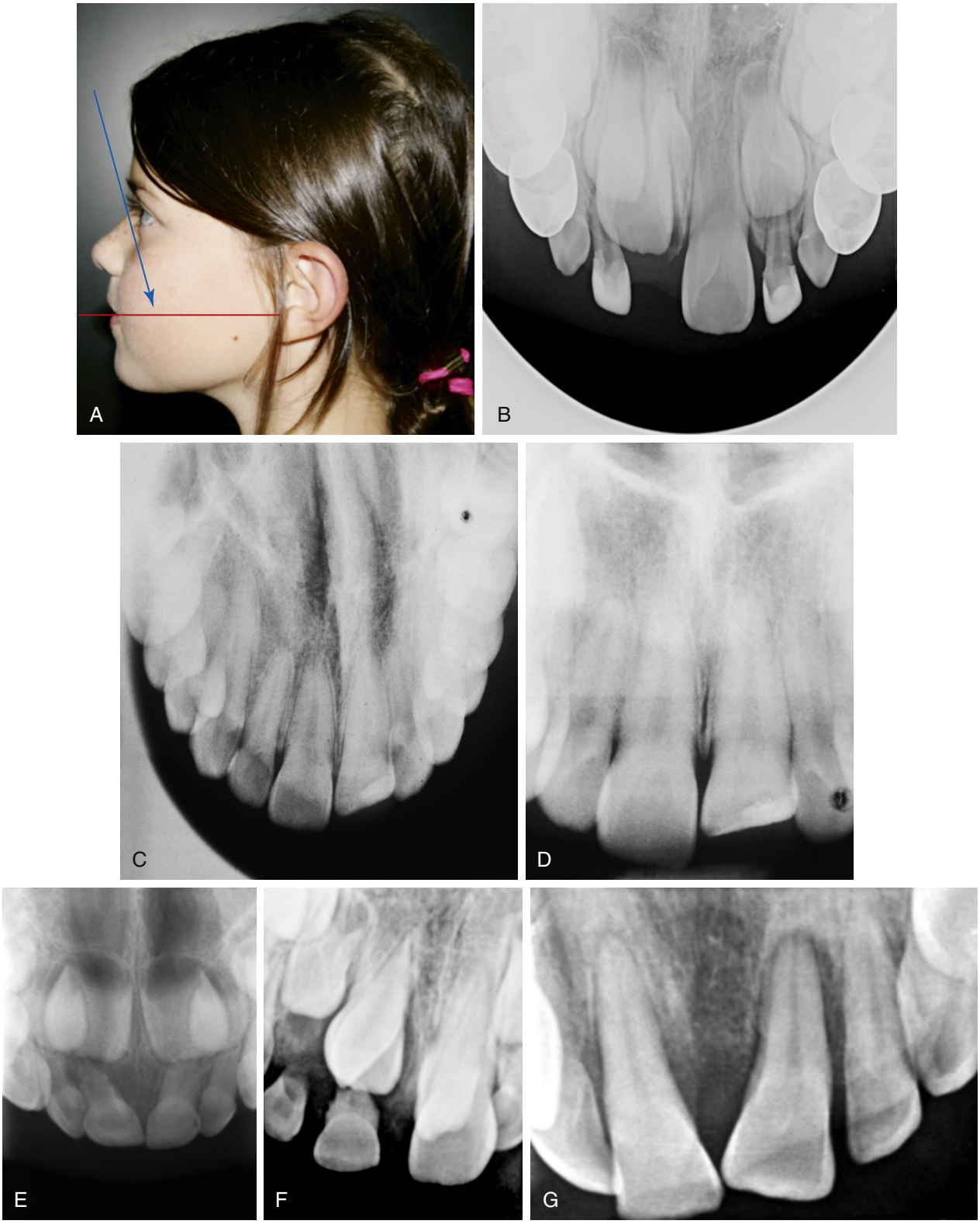

Figure 2-14 An occlusal radiograph in the maxilla should be taken with the patient in an upright position in the chair, with the occlusal plane (red line) horizontal to the floor and the x-ray beam (blue arrow) aimed at 60° to 65° through the bridge of the nose. The radiograph on the right shows the type of image obtained with this technique. The middle image illustrates that this technique does not necessitate the use of size 4 film or phosphor storage plates, but that size 2 will suffice (both images are from the same patient, but taken at different times). The bottom images illustrate the use of this technique in younger patients in the primary dentition and the mixed dentition, and in a special-needs patient with a dento-alveolar trauma (bottom right).

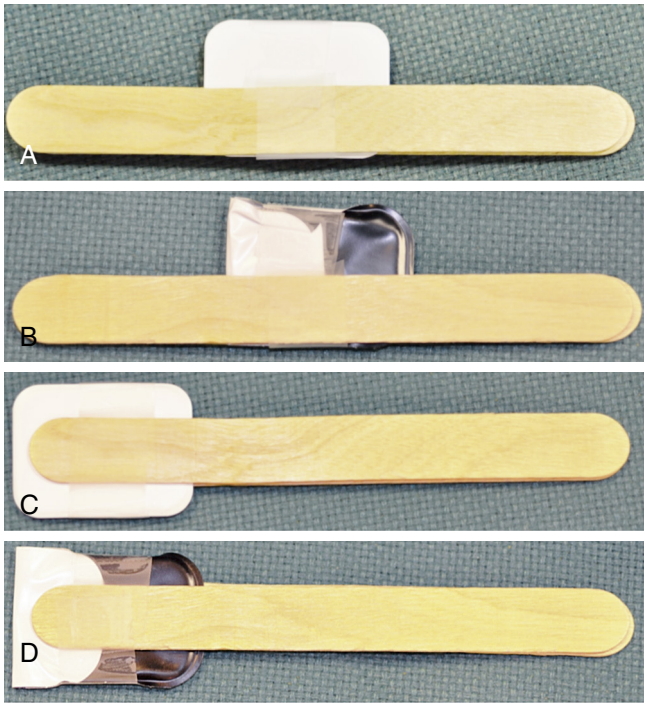

Figure 2-15 Illustration of wooden tongue depressors used to protect the film or phosphor plate from being bitten during positioning and/or exposure. The top two images are for anterior use and the bottom two are for posterior use. The image receptor is taped between two tongue depressors. The patient can bite down on them to avoid permanent damage to a phosphor plate. The tongue depressors provide guidance to the radiographer to assess the level of the occlusal plane or can provide assistance to the caregiver who assists during the radiographic procedure.

Using this principle for localization, the practitioner makes two radiographs of the unerupted tooth. The technique consists of positioning the patient's head so that the sagittal plane is perpendicular to the floor and the ala-tragus line is parallel to the floor. An intraoral periapical film is placed in the mouth and then exposed by the paralleling technique. Subsequently, a second film is placed in the mouth in the same position as the first film, with the patient's head position remaining the same, but with the horizontal angle shifted either anteriorly or posteriorly depending on the site. The object in the projection that moved in the direction opposite that in which the x-ray machine was moved is located more buccally, relative to the object(s) that moved in the same direction as the x-ray machine.

EXTRAORAL RADIOGRAPHY

Panoramic Imaging

The panoramic image is obtained through tomography. This means that only the structures located in the focal trough are captured in focus. Objects or structures outside the focal trough should be interpreted with care. Because of the projection geometry, panoramic images are magnified (by a factor of around 1.3), so measurements taken from a panoramic image will also be magnified.

Most current panoramic machines enable one to take bitewing look-alike images (Fig. 2-19). These images should be interpreted with caution since a standard bitewing projection requires that the image receptor be placed parallel to the teeth, with the x-ray beam directed perpendicular to the receptor. The panoramic bitewing is re-created from the existing panoramic image; nevertheless, it is a very useful alternative when a patient cannot tolerate the intraoral image receptor. However, it should not be used as a standard bitewing projection. Panoramic machines are available with solid-state sensors or with a cassette system. Film-based panoramic cassettes contain intensifying screens that convert x-radiation to visible light. Phosphor plate panoramic cassettes do not contain intensifying screens.

Cephalometric Imaging

This technique is usually used in orthodontics and orthognathic surgery. Some machines will use a single exposure, which minimizes motion errors. In the scanning machines, the exposure takes longer; hence there is a higher risk for motion artifacts in these images. Positioning of the patient in the cephalostat is very important. Remember that digital imaging does not correct or compensate for improper patient positioning.

Oblique Lateral Radiography

This technique offers an excellent alternative to bitewing radiographs, periapical radiographs, or panoramic images, when patients are unable to tolerate these techniques. The technique requires a cassette system (analog film or phosphor storage plate), held parallel to the midsagittal plane of the patient, while the x-ray beam is directed perpendicular to the cassette from behind or below the mandibular body. Figure 2-20 demonstrates the positioning of the patient, image receptor, and tube head. Figure 2-19 provides two examples of oblique lateral projections. This technique should not be regarded as a standard of care for every patient. Special-needs patients and small children can definitely benefit from this technique if a radiographic image is required.

Cone Beam Computed Tomography

This technology has become very popular in the past decade and has found its way into many private practices. This modality is ideal for imaging hard tissues. Artifacts due to beam hardening and motion artifacts are to be avoided (Fig. 2-21). The radiation dose from CBCT is considerably higher than that from a periapical radiograph. It is also very hard to determine the radiation dose in general from CBCT since it depends on exposure settings (kVp, mA, and exposure time), field of view (the size of the volume, which is determined by the size of the cone-shaped x-ray beam), and the resolution of the image (the details). Justification to expose pediatric patients to CBCT should not be taken lightly.

Medical Computed Tomography

Medical CT is responsible for the highest radiation doses a patient can receive from diagnostic imaging. The fan-shaped beam rotates around the patient's body (part) in a helical motion. The space between two rotations of the

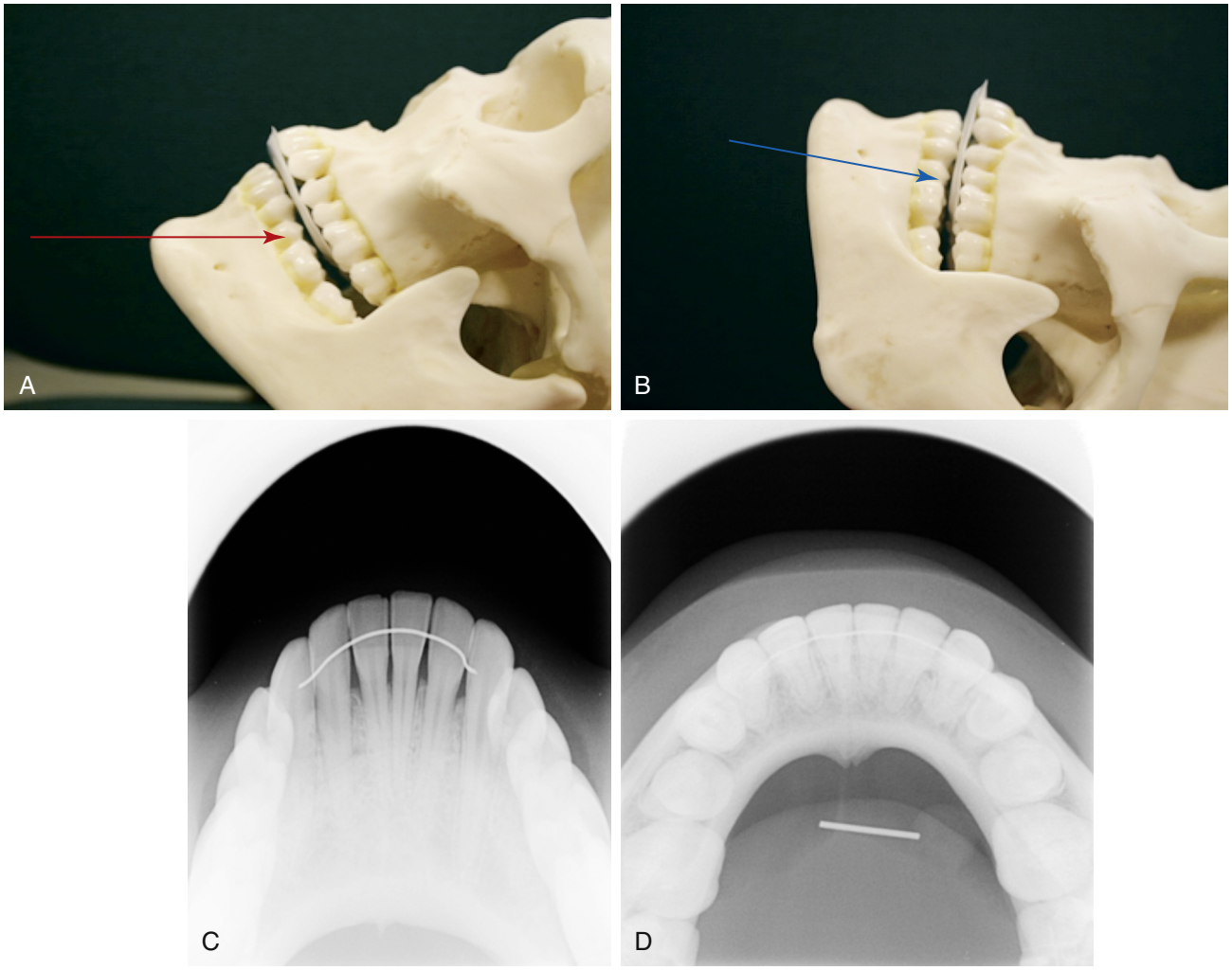

Figure 2-16 The top left image shows the position of the x-ray source (red arrow) 45° occlusal to the mandible. The bottom left shows an example of this projection. The top right image shows the position of the x-ray source (blue arrow) 90° occlusal to the mandible. The bottom right shows an example of this projection (patient with a small piece of a metal rod in the floor of the mouth).

beam (pitch) determines the resolution of the image and hence the radiation dose. Medical CT, also called multislice CT, is useful for the imaging of hard and soft tissues and provides the clinician with the ability to detect very small differences in density in the image (contrast resolution). The technique is usually used to identify malignancies, tumors, and other symptoms of pathology, with or without the use of contrast medium.

Ultrasound Imaging

Most people associate ultrasound imaging with pregnancy, but this technique also is excellent for investigation of soft tissues, such as the floor of the mouth, salivary glands, and lymph nodes in the head and neck region. Since the technique does not involve ionizing radiation, it can be repeated as many times as necessary, without exposing the patient to any risks. Figure 2-22 displays an ultrasonogram of the floor of the mouth as an illustration of an investigation to evaluate swelling or foreign objects in the soft tissues in this region. In addition, this technique is appropriate when fine-needle aspirations are required.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) evaluates the hydrogen content of tissues and uses a magnetic field to differentiate among different tissue types. Since there are more hydrogen atoms in soft tissues than in cortical bone, this technique is especially useful with soft tissue. Contraindications for MRI include claustrophobia and the presence of metallic clips or metallic foreign bodies. The most common dental indication for the use of MRI is for imaging the soft tissues of the temporomandibular joint (Fig. 2-23).

SELECTION CRITERIA AND RADIOGRAPHIC EXAMINATIONS

CRITERIA FOR EXPOSING CHILDREN TO IONIZING RADIATION

For all radiographic examinations, the same basic rules apply: justification and professional judgment on an individual patient basis. There are no guidelines per age group, gender, or dentition stage. The American Dental