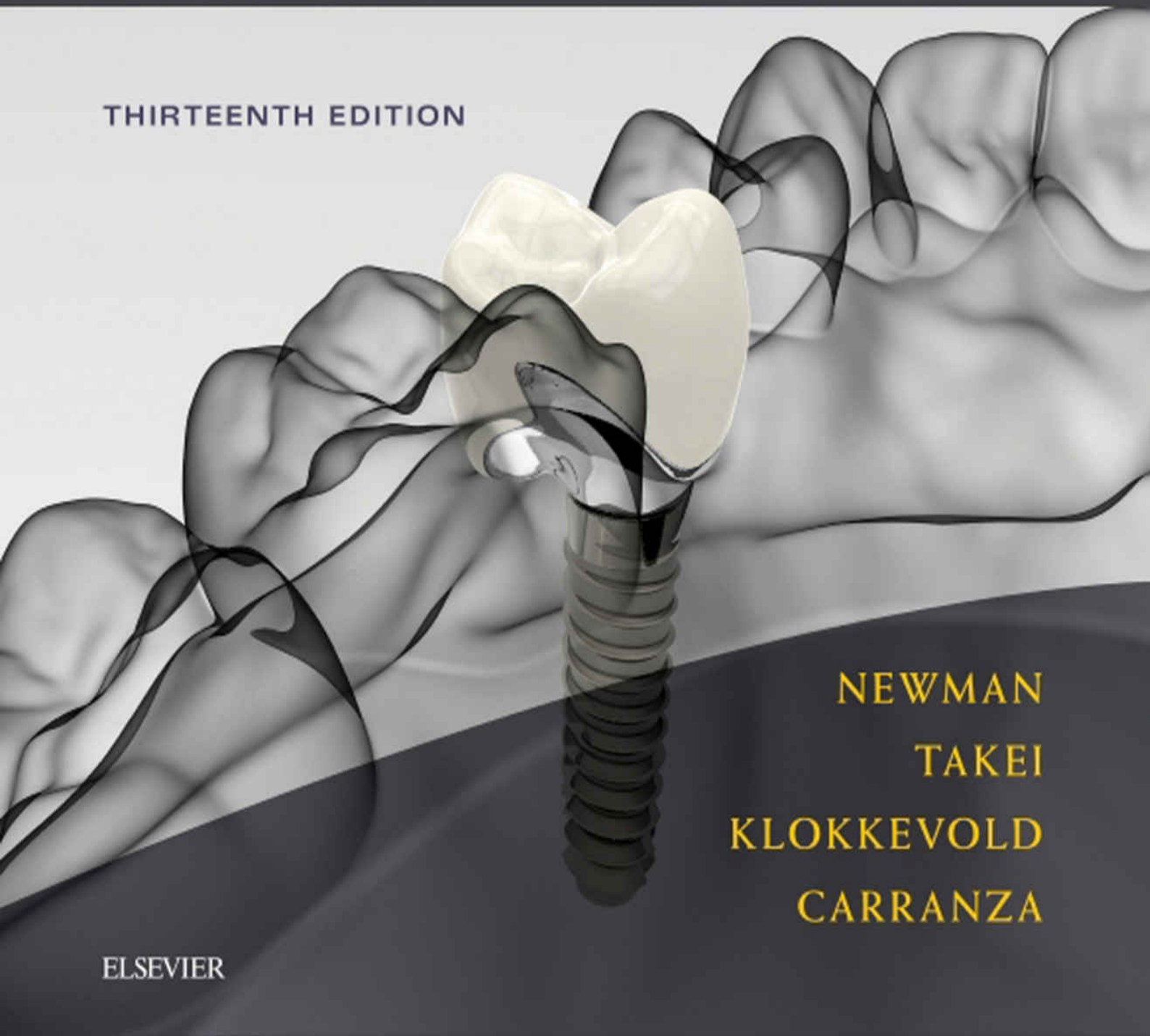
NEWMAN AND CARRANZA'S

CLINICAL PERIODONTOLOGY

THIRTEENTH EDITION



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Newman and Carranza's Clinical Periodontology

THIRTEENTH EDITION

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About the Book

Newman and Carranza's Clinical Periodontology, thirteenth edition, is the definitive global reference text in periodontics. Edited by Drs. Michael G. Newman, Henry H. Takei, Perry R. Klokkevold, editor emeritus Fermin A. Carranza, and associate editor Satheesh Elangovan, this book provides the highest quality information for students, residents, and practitioners.

The thirteenth edition is truly transformational. It fully engages modern information technology while maintaining and refining its decades of educational excellence. This edition improves on the previous one by more accurately reflecting the essential core information of periodontology and state-of-the-art methods in both the science and clinical knowledge base. Experts from more countries than ever have contributed to reflect a unifying view of the basic information related to the science and technology of modern periodontics.

The content on Expert Consult site is much improved in every aspect, including better speed, quality, functionality, access, and linking. There are more animations, videos, and case reports and one of the most comprehensive image libraries on periodontal pathology ever assembled. New case scenarios offer readers the opportunity to challenge their knowledge of integrated information in much more "real-life" patient encounters.

The print book is a complete and thorough presentation of periodontology essentials while retaining the style and quality that makes *Newman and Carranza's Clinical Periodontology* the number one periodontal textbook in the world. Advances in printing and

digital technology make this edition more “readable” than ever before.

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Dr. Takei has been honored nationally and internationally with awards from numerous periodontal organizations, universities, and study clubs for his contributions to education. He is also a Fellow of both the American College of Dentists and the International College of Dentists and has been elected into Omicron Kappa Upsilon.

He received the Distinguished Alumnus Award from Marquette

University in 2001 and the Honorary Distinguished Alumnus Award from UCLA in 1998. The American Academy of Periodontology has honored Dr. Takei with the prestigious Master Clinician Award in 2006. This award is the highest clinical recognition from this national periodontal organization. In 2016, two universities in Japan, Meikai University and Asahi University, presented Dr. Takei with the Honorary Doctorate Degree for many years of academic and clinical collaboration.

Perry R. Klokkevold, DDS, MS, FACD

Dr. Perry R. Klokkevold graduated from the University of California, San Francisco, School of Dentistry in 1986. His postdoctoral clinical training includes a General Practice Residency in Hospital Dentistry completed in 1987, a Postgraduate Periodontal Residency completed in 1994, and a Surgical Implant Fellowship completed in 1995. All of his postgraduate training was completed at the University of California, Los Angeles (UCLA), School of Dentistry. He earned a Master of Science degree in Oral Biology at UCLA in 1995.

Dr. Klokkevold is a Diplomate of the American Board of Periodontology and a Fellow of the American College of Dentists.

He is an Associate Professor in the Division of Constitutive and Regenerative Sciences, Section of Periodontics, at the UCLA School of Dentistry and Program Director of the UCLA Postgraduate Periodontics Residency program. Dr. Klokkevold served as Clinical Director and Program Director of the General Practice Residency program in Hospital Dentistry at the UCLA School of Dentistry from 1987 to 1992. He has maintained a faculty practice limited to the specialty of periodontics and dental implant surgery at UCLA since 1995.

Dr. Klokkevold has published more than 60 articles for international peer-reviewed journals and has written more than 100 book chapters for 13 books, including five editions of *Clinical Periodontology,* on topics including periodontal medicine, influence of systemic disease and risk factors on periodontitis to bone regeneration, and dental implants. He has served as a reviewer for several journals, among them the *Journal of Periodontology* and the *International Journal of Oral and Maxillofacial Implants*. Dr. Klokkevold lectures nationally and internationally on many periodontal and implant-related topics. He has been invited to serve as an expert consultant/reviewer for five international conferences organized by the American Academy of Periodontology and the Academy of Osseointegration on topics that include implant therapy, bone augmentation and implant site development, periodontal regeneration, and lasers in periodontal therapy.

Fermin A. Carranza, DR ODONT, FACD

Dr. Fermin A. Carranza graduated from the University of Buenos Aires School of Dentistry in Argentina in 1948 and completed his postdoctoral training in periodontics at Tufts University School of Dental Medicine in 1952 under the mentorship of Dr. Irving Glickman.

Dr. Carranza is Professor Emeritus of Periodontology at the University of California, Los Angeles (UCLA), School of Dentistry. He was head of the Department of Periodontics at the University of Buenos Aires from 1966 to 1974 and at UCLA from 1974 until his retirement in 1994.

Dr. Carranza has published more than 218 scientific papers and abstracts on basic and applied aspects of periodontics and 18 books, including the past five editions of *Clinical Periodontology.* He has received numerous awards and recognition for his work, including the IADR Science Award in Periodontal Disease and the Gies Award of the American Academy of Periodontology.

Dr. Carranza has lectured throughout the world on clinical periodontology, pathology, and therapy.

Preface

With the help of Elsevier's advanced technology and high standards of quality, an international team of editors and contributors have developed the most comprehensive periodontal resource available, *Newman and Carranza's Clinical Periodontology*, thirteenth edition. The book's companion website is rich with images, animations, videos, question sets, case reports, PowerPoint slides, audio slides, virtual microscope, multidisciplinary case scenarios, and more. No other resource offers such a comprehensive approach to providing high quality content.

Since publication of the first edition of this book in 1953, periodontology has made tremendous advancements. Scientific analysis of periodontal tissues and the elucidation of mechanisms and causes of disease have extended far beyond histology and physiology into the realm of cellular and molecular biologic understanding.

Implant dentistry has become a major component of periodontology, and this book offers a wide coverage of important treatment modalities.

New therapeutic goals and clinical techniques, based on an improved understanding of disease and healing, have facilitated better outcomes and brought us closer to achieving the ultimate goal of optimal periodontal health and function. Today, reconstruction and regeneration of lost periodontal structures, replacement of compromised teeth with implants, and creation of aesthetic results are integral parts of clinical practice.

The multifaceted, complex task of producing the thirteenth edition required the collaboration of numerous experts from

various fields, and their contributions are invaluable. We know that this new edition will continue to be a useful resource for to dentists, dental hygienists, periodontists, students, educators, and researchers.

Having this resource available will contribute to the continuous progress of our profession.

Michael G. Newman

Henry H. Takei

Perry R. Klokkevold

Fermin A. Carranza

Acknowledgments

Clinical Periodontology has been a trusted and valuable periodontics resource for students, residents, academicians, scientists, and clinicians since the early 1950s. Dr. Irving Glickman was the originator and author of *Clinical Periodontology* for the first four editions, which were published in 1953, 1958, 1964, and 1972. Dr. Glickman was professor and chairman of the Department of Periodontology at Tufts University School of Dental Medicine, in Boston, Massachusetts.

Dr. Fermin A. Carranza, once a student of and collaborator with Dr. Glickman, assumed responsibility to author and continue the book after Dr. Glickman's death in 1972 at age 58. Dr. Carranza was professor and chairman of periodontics at the University of California, Los Angeles (UCLA), School of Dentistry. The subsequent four editions were published in 1979, 1984, 1990, and 1996 under the leadership and guidance of Dr. Carranza.

Dr. Michael G. Newman joined Dr. Carranza in 1996 as co-editor of the eighth edition. Dr. Newman was adjunct professor of periodontics at the UCLA School of Dentistry. Dr. Carranza retired to become professor emeritus at UCLA, and the responsibility of maintaining the book's tradition of almost half a century changed hands once again, this time to Dr. Newman. The subsequent four editions were published in 2002, 2006, 2012, and 2015 under the direction of Dr. Newman. The title of the ninth edition was changed from *Clinical Periodontology* to *Carranza's Clinical Periodontology* to acknowledge and honor Dr. Carranza for his leadership and dedication to this renowned resource.

Dr. Henry H. Takei joined Dr. Newman and Dr. Carranza in 2002 as co-editor of the ninth edition. Dr. Takei was clinical professor of periodontics at the UCLA School of Dentistry. Dr. Takei currently holds the title of Distinguished Clinical Professor of Periodontics at UCLA School of Dentistry.

Dr. Perry R. Klokkevold joined Drs. Newman, Takei, and Carranza in 2006 as co-editor of the tenth edition. Dr. Klokkevold is an associate professor and the program director of Postgraduate Periodontics at the UCLA School of Dentistry. Dr. Carranza became editor emeritus for the tenth and subsequent editions.

The title of the thirteenth edition has been changed to *Newman and Carranza's Clinical Periodontology* to acknowledge and recognize Dr. Newman's leadership in maintaining the book's reputation as a high-quality and forward-looking resource for those who practice periodontology and implant dentistry.

The level of understanding and the practice of clinical periodontics have evolved tremendously since the mid-20th century. Advances in basic science and clinical techniques have increased the knowledge base so dramatically that it is virtually impossible for individuals to master and retain all the information.

It is also certain that the task of researching, preparing, and assembling the enormous amount periodontology-related content necessary for this book had to be borne by many experts who shared their experience and knowledge. We express our deep gratitude to all the contributors whose expertise, ideas, and efforts built this valuable resource over the years. Many scientists and clinicians have shared their wisdom and expertise in previous editions of *Carranza's Clinical Periodontology*, as associate editors, section editors, and contributors, though some of their names no longer appear.

Our appreciation is given to Elsevier and particularly to Jennifer Flynn-Briggs and Lucia Gunzel. Their expertise and detailed attention to every word and every concept contributed greatly to producing a quality book and a truly useful website.

We also express appreciation to Dr. Satheesh Elangovan who joined the team for the thirteenth edition as associate editor. The

online version of the book continues to assume greater importance to our readers. Elsevier's electronic capabilities provide a rich, useful, and complete resource and are directed by Dr. Elangovan.

We express gratitude to our parents, colleagues, friends, and mentors who have always been so tolerant, encouraging, and understanding and who guided our first steps in our profession and helped us develop our ideas in the field.

Dr. Newman: My family, Susan, Andrea, Kara, Callahan and Natalie, Scott, Zoey and Eleanor; my parents, Paul, Rose, John, and Inez. Sigmund S. Socransky, Fermin A. Carranza, Jr., and Henry H. Takei. My gratitude to my co-editors and contributors whose expertise and willingness to participate in this work have made this book an excellent educational standard.

Dr. Takei: My wife, June; my children, Scott and Akemi; their spouses, Kozue and David; my grandchildren, Hana, Markus, Carter, and Arden. My graditude to my mentors Dr. Fermin A. Carranza, Jr., Dr. Donald Van Scotter, Dr. Delbert Nachazel, and Dr. John Pfeiffer. Thank you to my three co-editors and friends Michael G. Newman, Fermin A. Carranza, Jr., and Perry R. Klokkevold. Special gratitude to Laura Miyabe for her professional support. I would like to acknowledge and thank all of my periodontal postdoctoral students at UCLA for their help and support throughout the preparation of this classic textbook. Another note of thank you to Dr. Sasan Garakani for the many hours of collaboration and help that he provided in the review of literature and organizing the references for numerous chapters.

Dr. Klokkevold: My wife, Angie; my daughters, Ashley and Brianna; my parents Carl and Loretta; my gratitude and appreciation to my mentors Dr. Henry H. Takei, Dr. John Beumer III, Dr. Bradley G. Seto, Dr. Charles N. Bertolami, and Dr. Thomas Han. I am grateful to the many talented residents who matriculated through UCLA Postgraduate Periodontics for the passion and inspiration they bring to me as an educator and clinician. Finally, I give special thanks to my co-editors, Dr. Michael G. Newman, Dr. Henry H. Takei, and Dr. Fermin A. Carranza, Jr., for their friendship, support, and encouragement.

Dr. Carranza: My wife, Rita; my children, Fermin, Patricia, and Laura; and my grandchildren, Irving Glickman, Fermin Carranza, Sr., and Romulo L. Cabrini. My gratitude also to my co-editors, who will continue the tradition of this book.

Michael G. Newman

Henry H. Takei

Perry R. Klokkevold

Fermin A. Carranza

Video Contents

Introduction: The Historical Background of Periodontology

Gerald Shklar [†], *Fermin A. Carranza*

Chapter Outline

Gingival and periodontal diseases have afflicted humans since the dawn of history. Studies in paleopathology have indicated that destructive periodontal disease, as evidenced by bone loss, affected early humans in such diverse cultures as ancient Egypt and early

pre-Columbian America. The earliest historical records that involve medical topics reveal an awareness of periodontal disease and the need for treatment. Almost all early writings that have been preserved have sections or chapters dealing with oral diseases, and periodontal problems comprise a significant amount of space in these writings. Calculus and systemic disease were frequently postulated as causes of periodontal disorders.

However, methodic and carefully reasoned therapeutic discussions did not exist until the Arabic surgical treatises of the Middle Ages. Modern treatment, with illustrated text and sophisticated instrumentation, did not develop until the time of Pierre Fauchard during the eighteenth century.

Early Civilizations

Oral hygiene was practiced by the Sumerians, the Babylonians, and the Assyrians; this included gingival massage in combination with various herbal medications.[25,33]

Periodontal disease was the most common of all diseases found in the embalmed bodies of the ancient Egyptians.[7,44] The Ebers papyrus contains many references to gingival disease and offers a number of prescriptions for strengthening the teeth and gums.[14]

The medical works of ancient India and China devote significant space to oral and periodontal problems and oral hygiene,[47] and they describe gingival inflammations, periodontal abscesses, and gingival ulcerations.[12,21] The early Hebrews also recognized the importance of oral hygiene. Many pathologic conditions of the teeth and their surrounding structures are described in the Talmudic writings.

The Classical World

Among the ancient Greeks, Hippocrates of Cos (460 BC-377 BC), the father of modern medicine, discussed the function and eruption of the teeth and the etiology of periodontal disease. He believed that inflammation of the gums could be caused by accumulations of "pituita" or calculus, with gingival hemorrhage occurring in cases of persistent splenic maladies.[10,27]

Among the Romans, Aulus Cornelius Celsus (25 BC-50 AD) referred to diseases that affect the soft parts of the mouth and their treatment, including oral hygiene. Paul of Aegina (625 AD-690 AD) wrote that tartar deposits must be removed with either scrapers or a small file and that the teeth should be carefully cleaned after the last meal of the day.[41]

The Middle Ages

The decline and fall of the Roman Empire that plunged Europe into an age of darkness was accompanied by the rise of Islam and the golden age of Arabic science and medicine. The Arabic treatises derived their information from Greek medical treatises, but many refinements and novel approaches were added, particularly in surgical specialties.[45]

Albucasis (936-1013) was born and lived in Moorish Spain. His 30-volume medical encyclopedia, called *al-Tasrif,* was translated into Latin during the twelfth century, and it was the medical text used in European universities until the seventeenth century. The contributions of Albucasis to dentistry and periodontology were outstanding achievements.[1] He had a clear understanding of the major etiologic role of calculus deposits, and he described the techniques of scaling the teeth with the use of a set of instruments that he developed (Fig. I.1), splinting loose teeth with gold wire, and filing gross occlusal abnormalities.

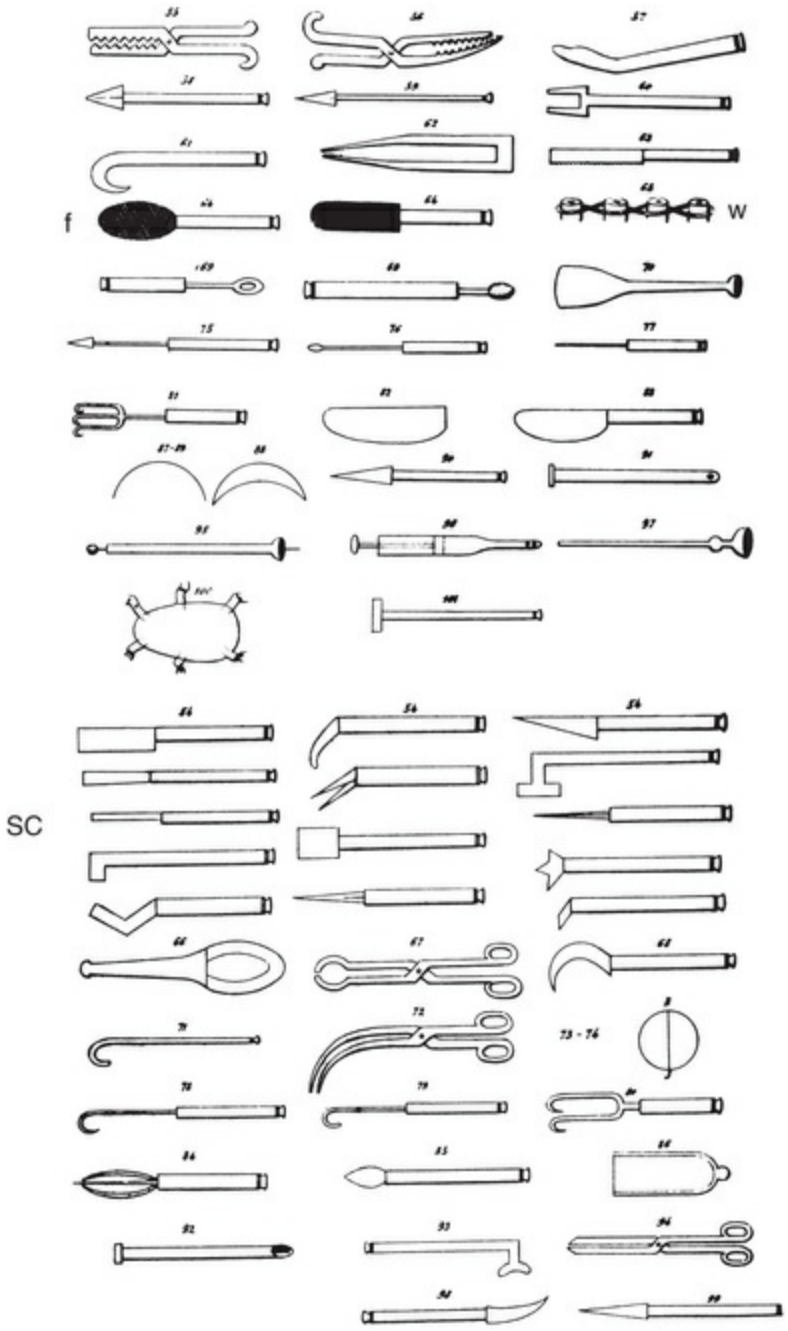


FIG. I.1 Illustration of Albucasis' periodontal instruments, showing scalers *(sc),* files *(f),* and the wiring of loose teeth *(w).*

Avicenna (980-1037) was possibly the greatest of the Persian physicians. His *Canon,* a comprehensive treatise on medicine, was in continuous use for almost 600 years. Avicenna used an extensive "materia medica" for oral and periodontal diseases and rarely resorted to surgery.[3]

The Renaissance

During the Renaissance—with the rebirth of classical scholarship, the development of scientific thought and medical knowledge, and the flowering of art, music, and literature—significant contributions were made to anatomy and surgery.

Albucasis' work was expanded during the fifteenth century by the Turkish author Serefeddin Sabuncuoglu (1385-1468), who included illustrations of the surgical removal of hypertrophic and swollen gingiva and lingual frenum (Fig. I.2). Drug treatment should be initiated if there are swollen gums, mobile teeth, and pus formation. If there is no response, surgical treatment should be performed. A tube is placed on the gums. A hot cautery is inserted into the cannula, and the gingival tissue is cauterized. If this is correctly applied, the adjacent teeth will be warm.

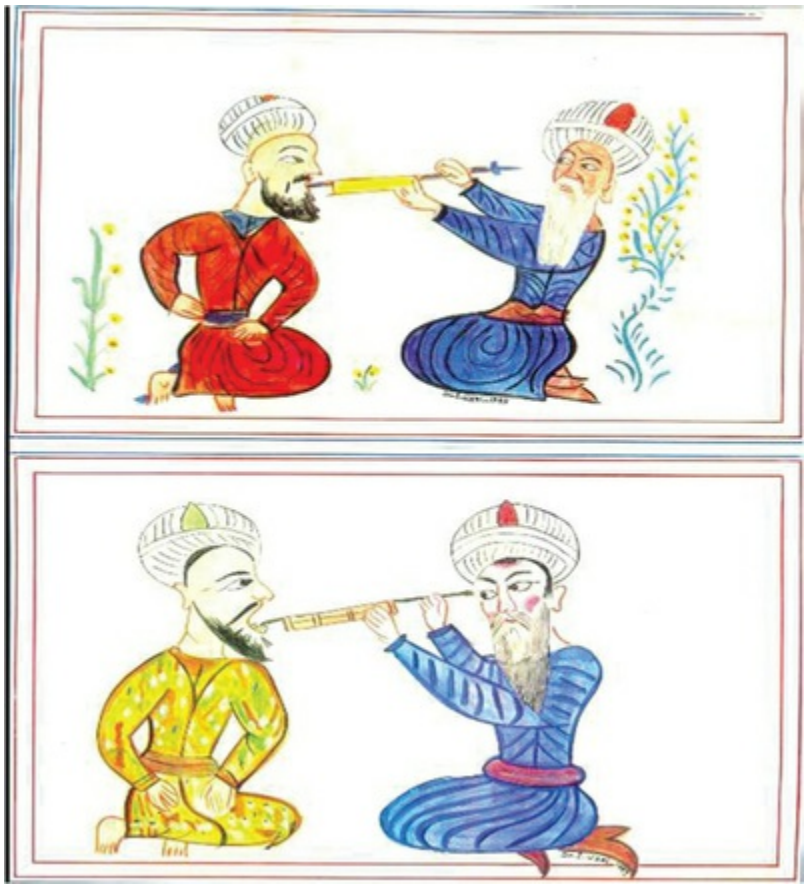


FIG. I.2 Illustration by Serefeddin Sabuncuoglu showing gingival cauterization. (From Abulcasis and redrawn by Professor Ilter Uzel, Turkey.)

Paracelsus (1493-1541) developed an interesting and unusual theory of disease: the doctrine of calculus. Paracelsus recognized the extensive formation of tartar on the teeth and related this to toothache. He considered toothache to be comparable to the pain produced by calculus in other organs, such as the kidneys.[39]

Andreas Vesalius (1514-1564), who was born in Brussels, taught at the University of Padua and wrote a magnificent book about anatomy that included many excellent illustrations.[48] Bartholomeus Eustachius (1520-1574) of Rome was another outstanding anatomist who wrote a small book about dentistry, *Libellus de Dentibus* ("A Little Treatise on the Teeth"), which contained 30 chapters.[16] This was the first original book about the teeth, and it included a description of the periodontal tissues as well as information about the diseases of the mouth, their treatment modalities, and the rationale for treatment. For the treatment of periodontitis, Eustachius recommended both the scaling of calculus and the curettage of granulation tissue so that actual reattachment of the gingival and periodontal tissues could take place.

The Frenchman Ambroise Paré (1509-1590) was the outstanding surgeon of the Renaissance, and his contributions to dental surgery included gingivectomy for hyperplastic gingival tissues.[40] He also understood the etiologic significance of calculus and used a set of scalers to remove the hard deposits on the teeth.

The first book in the common language of German and specifically devoted to dental practice, which was entitled *Artzney Buchlein* or *Zene Artzney* ("Medicine of the Teeth"), was published in Leipzig in 1530.[2] It contains three chapters devoted to periodontal problems, including a crude concept of systemic and local factors in the etiology of periodontal disease. The presence of local infective agents or "worms" is also mentioned.

A variety of ointments, which are often astringent in nature, is suggested, and the binding of loose teeth to sound ones with silk or gold thread is recommended. Cauterizing the gingiva with a hot iron is mentioned.

The Italian physician, mathematician, and philosopher Girolamo Cardano (1501-1576) appears to have been the first to differentiate among the types of periodontal disease. In a publication dated 1562, he mentions one type of disease that occurs with advancing age and

leads to progressive loosening and loss of teeth as well as a second very aggressive type that occurs in younger patients.[26] It was not until late in the twentieth century that this classification was rediscovered and became widely accepted.

Anton van Leeuwenhoek (1632-1723) of Delft, Holland, was a layman, but he had an inquisitive mind and a hobby of grinding lenses that allowed him to develop the microscope. He used it to discover microorganisms, cellular structure, blood cells, sperm, and various other microscopic structures, including the tubular structure of dentin.[9,13] Using material from his own mouth, Leeuwenhoek first described oral bacterial flora, and his drawings offered a reasonably good presentation of oral spirochetes and bacilli (Fig. I.3). He even performed antiplaque experiments involving the use of strong vinegar in his own mouth and in vitro on bacteria in a dish.[13]

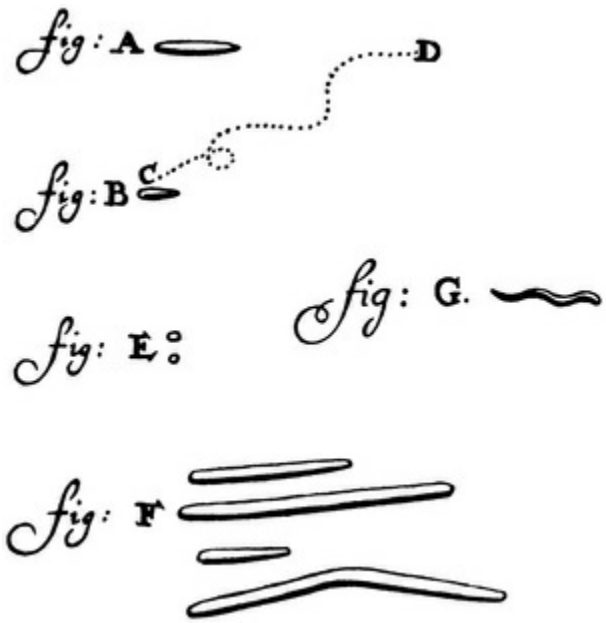
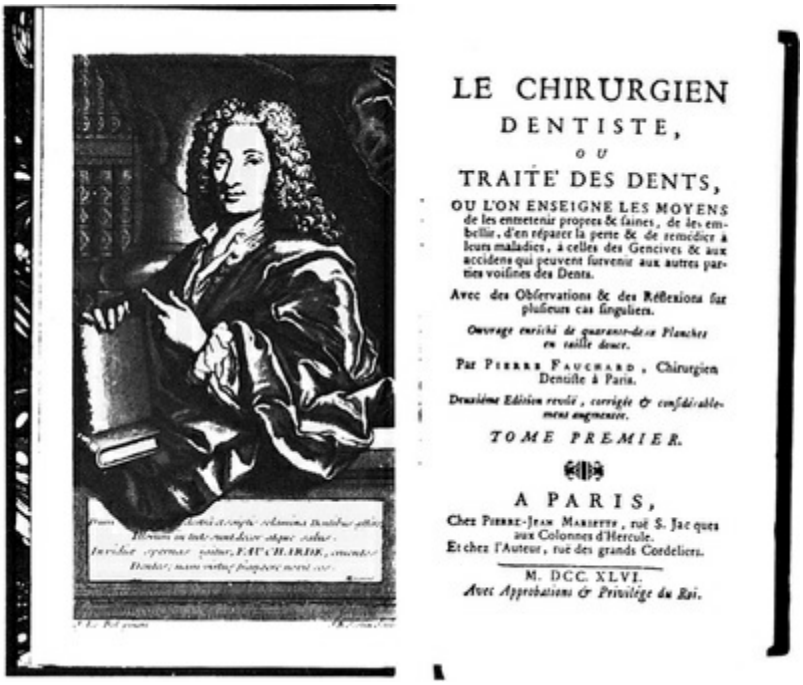


FIG. I.3 Leeuwenhoek's drawing of oral spirochetes, bacilli, and other microorganisms.

The Eighteenth Century

Modern dentistry essentially developed in eighteenth century Europe, particularly France and England. Pierre Fauchard, who was

born in Brittany in 1678, is rightly regarded as the father of the dental profession as we know it. His book, *The Surgeon Dentist,* which was published in 1728, covered all aspects of dental practice, including restorative dentistry, prosthodontics, oral surgery, periodontics, and orthodontics[17] (Fig. I.4). Fauchard described in detail his periodontal instruments and the scaling technique for using them (Fig. I.5).



LE CHIRURGIEN
DENTISTE,
OU
TRAITÉ DES DENTS,
OU L'ON ENSEIGNE LES MOYENS de les entretenir propres & saines, de les embellir, d'en réparer la perte & de remédier à leurs maladies, à celles des Gencives & aux accidens qui peuvent survenir aux autres parties voisines des Dents.
Avec des Observations & des Réflexions sur plusieurs cas singuliers.
Ouvrage enrichi de quarante-deux Planches en taille douce.
Par PIERRE FAUCHARD, Chirurgien Dentiste à Paris.
Deuxième Edition revûë, corrigée & considérablement augmentée.
TOME PREMIER.
A PARIS,
Chez PIERRE-JEAN MARIETTE, ruë S. Jacques aux Colonnes d'Hercule.
Et chez l'Auteur, ruë des grands Cordeliers.
M. DCC. XLVI.
Avec Approbation & Privilége du Roi.

FIG. I.4 Frontispiece of Fauchard's book entitled *The Surgeon Dentist* (1746 edition).

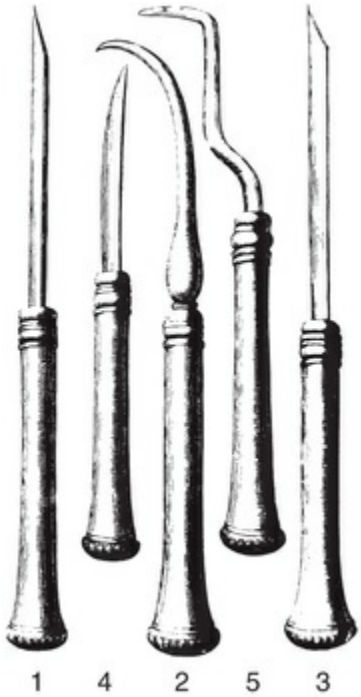


FIG. I.5 The five types of instruments used by Fauchard for detaching tartar from the teeth: *1*, chisel; *2*, parrot beak; *3*, graver; *4*, convex blade; and *5*, Z-shaped hook.

John Hunter (1728-1793), who was the most distinguished anatomist, surgeon, and pathologist of eighteenth-century England, wrote an excellent treatise on dentistry entitled *The Natural History of the Human Teeth.*[30] He offered remarkably clear illustrations of the anatomy of the teeth and their supporting structures, and he described the features of periodontal diseases.

A contemporary of Hunter, Thomas Berdmore (1740-1785), was considered the outstanding dentist in England. In 1770, he published a book that had several chapters devoted to periodontal problems.[4]

The Nineteenth Century

Leonard Koecker (1785-1850) was a German-born dentist who practiced in Baltimore. In a paper in 1821, he mentioned the careful removal of tartar and the need for oral hygiene by the patient, recommending that it be performed in the morning and after every meal with the use of an astringent powder and a toothbrush, with care taken to place "the bristles … into the spaces of the teeth."

Koecker was an early advocate of the "odontogenic focal infection" theory, and he recommended the extraction of all severely involved teeth and roots, including all unopposed molars, to prevent systemic infections.[35]

Levi Spear Parmly (1790-1859) was a New Orleans, Louisiana, dentist who is considered the father of oral hygiene and the inventor of dental floss.[11,18]

During the mid-nineteenth century, John W. Riggs (1811-1885) was the leading authority on periodontal disease and its treatment in the United States; in fact, at the time, periodontitis was known as "Riggs' disease" (Fig. I.6). Riggs graduated from the Baltimore College of Dental Surgery in 1854 and practiced in Hartford, Connecticut, where he died on November 11, 1885. Riggs seems to have been the first individual to limit his practice to periodontics and therefore can be considered the first specialist in this field. Riggs' publications, however, are limited. In an 1876 paper, Riggs was a strong proponent of the so-called conservative approach to periodontal therapy; he developed the concept of oral prophylaxis and prevention, advocated for the cleanliness of the mouth, and opposed surgery, which at the time consisted of gingival resection.[43]

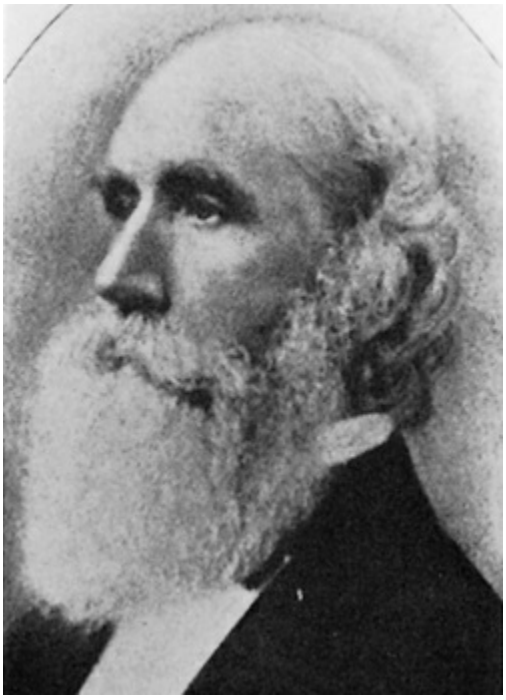


FIG. I.6 John W. Riggs (1811-1885). (From Hoffman-Axthelm W: *History of dentistry,* Chicago, 1981, Quintessence.)

Riggs and his disciples had great influence on the dental profession. Among Riggs' followers were L. Taylor, D.D. Smith, R.B. Adair, and W.J. Younger. The instruments designed by Younger[57] and later modified by his student Robert Good were used widely until well beyond the middle of the twentieth century.

Several major developments in medical science occurred during the second half of the nineteenth century and started the era that can be called *modern medicine,* which includes dentistry.[9,36] The first was the discovery of anesthesia by Horace Wells (1813-1848) of Hartford, Connecticut, in 1845 and by William Morton (1819-1868) of Boston, Massachusetts, in 1846, who discovered the general anesthetic effects of nitrous oxide and ether, respectively. *Local anesthesia* was developed by the Vienna ophthalmologist Carl Köller (1857-1944), who produced anesthesia of the eye with drops of cocaine. Procaine (Novocaine) was developed in 1905 by the Munich chemists Alfred Einhorn and Richard Willstädter. Later, with the addition of adrenaline, which was discovered separately in the United States by Jokichi Takamine and Thomas Bell Aldrich, local anesthesia was born.[29]

The second scientific breakthrough was made by the French chemist Louis Pasteur (1822-1895), who established the *germ theory of disease.* Subsequently, the German physician Robert Koch (1843-1910), in a series of brilliant investigations, discovered the microorganism that causes the cattle disease anthrax and the bacterial etiology of tuberculosis and cholera.

The concepts of Pasteur were transferred to clinical and surgical practice by Joseph Lister (1827-1912) of England, and thus the era of antisepsis—and later, asepsis—in surgery was born. Anesthesia and antisepsis made possible extraordinary advances in surgical techniques.

Pasteur, Koch, and their collaborators and followers—Elie Metchnikoff, Emile Roux, Paul Ehrlich, Emil von Behring, Shibasaburo Kitasato, and many others—discovered the bacterial etiologies of numerous diseases (e.g., pneumonia, puerperal fever, diphtheria, meningitis, plague, dysentery, syphilis) and gave birth to two sciences that became basic to periodontics: bacteriology and immunology.

A third scientific finding that changed the practice of dentistry in

general and of periodontics in particular was the *discovery of radiographs* by the German physicist Wilhelm Röntgen (1845-1923; also written as *Roentgen*). Röntgen's discovery was made in 1895 at the University of Würzburg and was purely a basic science finding, but it was immediately taken up by physicians and dentists, and it proved to be a crucial development in periodontics and many other areas of medicine and dentistry.

Also during the late nineteenth century, studies by Rudolph Virchow (1821-1902), Julius Cohnhein (1839-1884), Elie Metchnikoff (1845-1916), and others had started to reveal the microscopic changes that occur during inflammation.[8,9] This resulted in an understanding of the pathogenesis of periodontal disease on the basis of histopathologic studies. The Russian N.N. Znamensky described the complex interaction of local and systemic factors in the etiology of periodontal disease. His observations and concepts were summarized in 1902 in a classic paper in which he described the presence in inflamed gingivae of a cellular infiltrate that extends deeper as the disease progresses, thereby causing the bone resorption associated with multinucleated cells (osteoclasts) and Howship lacunae[58] (Fig. I.7).

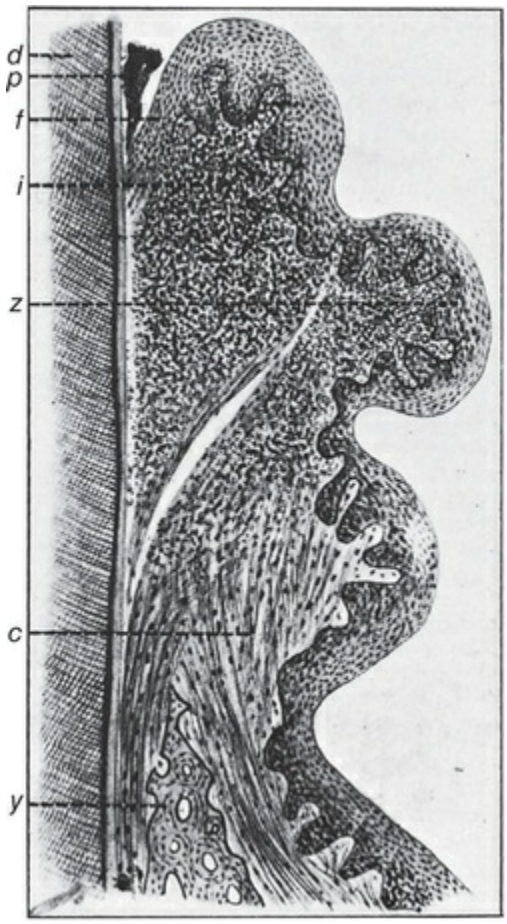


FIG. I.7 Microscopic features of periodontal disease as presented by Znamensky.

The first individual to identify bacteria as the cause of periodontal disease appears to have been the German dentist Adolph Witzel (1847-1906).[23,56] The first true oral microbiologist, however, was the American Willoughby D. Miller (1853-1907), whose professional activities took place in Berlin, where he embarked on a research career that introduced modern bacteriology principles to dentistry. Although his greatest accomplishments were in caries research, in his classic book, *The Microorganisms of the Human Mouth,* which was published in 1890, he described the features of periodontal disease and considered the role of predisposing factors, irritational factors, and bacteria in its etiology. He believed that the disease was not caused by a specific bacterium but by a complex array of various bacteria that are normally present in the oral cavity. This constitutes what was later known as the *nonspecific plaque hypothesis,* which went unchallenged for seven decades.[23,37]

Bacterial plaque was described by J. Leon Williams (1852-1932), an American dentist who practiced in London and who in 1897 described a gelatinous accumulation of bacteria adherent to the enamel surface in relation to caries.[55] In 1899, G.V. Black (1836-1915) coined the term *gelatinous microbic plaque*.[5]

Salomon Robicsek (1845-1928) was born in Hungary and practiced dentistry in Vienna. He developed a surgical technique that consisted of a scalloped, continuous gingivectomy excision that exposed the marginal bone for subsequent curettage and remodeling.[46]

The first description in 1901 of a possible role of trauma from occlusion and bruxism in periodontal disease is generally attributed to the Austrian dentist Moritz Karolyi (1865-1945), who also recommended its correction by grinding occlusal surfaces and preparing bite plates.[34]

Necrotizing Ulcerative Gingivitis

Necrotizing ulcerative gingivitis had been recognized during the fourth century BC by Xenophon, who mentioned that Greek soldiers were affected with "sore mouth and foul-smelling breath." In 1778, Hunter described the clinical features of this disease and differentiated it from scurvy and chronic periodontitis.

Hyacinthe Jean Vincent (1862-1950),[23,49] a French physician working at the Pasteur Institute in Paris, and Hugo Carl Plaut (1858-1928)[42] in Germany described the spirillum and fusiform bacilli associated with what later became known as *Vincent's angina*. In 1904, Vincent described the presence of these organisms in ulceronecrotic gingivitis.[50]

The Twentieth Century

During the first third of the twentieth century, periodontics flourished in central Europe, with two major centers of excellence: Vienna and Berlin.[22]

Vienna

The Vienna school developed the basic histopathologic concepts on which modern periodontics was built. The major representative from this group was Bernhard Gottlieb (1885-1950), who published extensive microscopic studies of periodontal disease in human autopsy specimens (Fig. I.8).[19] His major contributions appeared in the German literature during the 1920s, and they described the attachment of the gingival epithelium to the tooth, the histopathology of inflammatory and degenerative periodontal disease, the biology of the cementum, active and passive tooth eruption, and traumatic occlusion. A book published in 1938 by Gottlieb and Orban presented a complete review in English of the concepts developed by Gottlieb and his coworkers in Vienna.[24]

FIG. I.8 Bernhard Gottlieb (1885-1950). (From Gold SI: *J Clin Periodontol* 12:171, 1985.)

A younger contemporary of Gottlieb's in Vienna was Balint J. Orban (1899-1960) (Fig. I.9), who carried out extensive histologic studies on periodontal tissues. These studies serve as the basis for much of current therapy. Other members of the Viennese school were Rudolph Kronfeld (1901-1940), Joseph P. Weinmann (1889-1960), and Harry Sicher (1889-1974). All of these scientists emigrated to the United States during the 1930s and contributed

greatly to the progress of American dentistry.

FIG. I.9 Balint J. Orban (1899-1960). (From *J Periodontol* 31:266, 1960.)

Berlin

The Berlin group consisted mostly of clinical scientists who developed and refined the surgical approach to periodontal therapy. Prominent in this group were Oskar Weski (Fig. I.10) and Robert Neumann (Fig. I.11).

FIG. I.10 Oskar Weski (1879-1952). (From Hoffman-Axthelm W: *History of dentistry,* Chicago, 1981, Quintessence.)

FIG. I.11 Robert Neumann (1882-1958). (Courtesy Dr. Steven I. Gold, New York.)

Weski (1879-1952) carried out pioneering studies that correlated radiographic and histopathologic changes in patients with periodontal disease.[53] He also conceptualized the periodontium as being formed by the cementum, gingiva, periodontal ligament, and bone, and he gave it the name *paradentium;* this was later changed for etymologic reasons to *parodontium,* which is a term that is still used in Europe.

Neumann (1882-1958), in a book published in 1912[38] (with new editions in 1915, 1920, and 1924), described the principles of periodontal flap surgery, including osseous recontouring as it is currently known[20] (Fig. I.12). Other clinicians who described flap surgery at the beginning of the twentieth century were Leonard Widman of Sweden (1871-1956)[54] and A. Cieszynski of Poland. A bitter controversy developed among Widman, Cieszynski, and Neumann during the 1920s with regard to the priority of describing the periodontal flap.

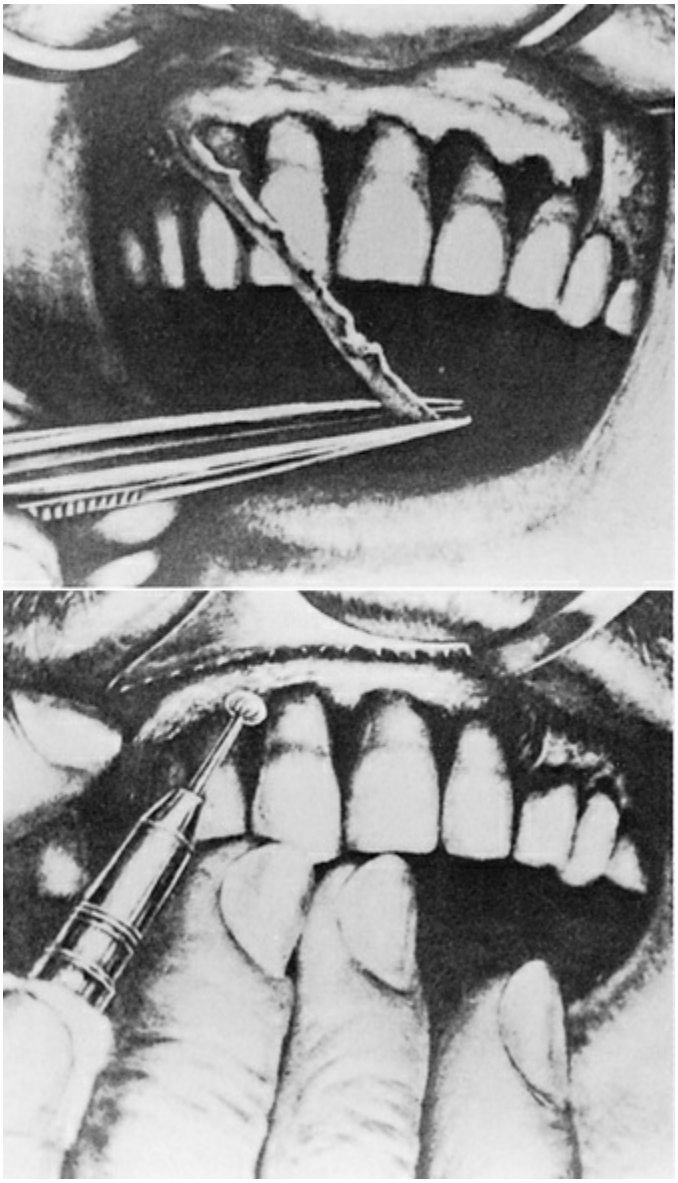


FIG. I.12 Surgical procedure advocated by Robert Neumann during the early part of the twentieth century. *Top,* After raising a mucoperiosteal flap, its edge is trimmed with scissors to leave a scalloped outline. *Bottom,* Osseous recontouring with burs. (From Gold SI: *J Periodontol* 53:456, 1982.)

The United States and Other Countries

In the United States, before World War II, important contributions to periodontal surgery were made by A. Zentler, J. Zemsky, G.V. Black, O. Kirkland, A.W. Ward, A.B. Crane, H. Kaplan, and others. In 1923, Ward introduced the surgical pack under the trade name Wondr-Pak.[51]

The nonsurgical approach was championed by Isadore Hirschfeld (1882-1965) of New York, who wrote classic papers about oral hygiene,[28] local factors, and other topics. In 1913, Alfred Fones (1869-1938) opened the first school for dental hygienists in Bridgeport, Connecticut.[9]

In other countries, H.K. Box (Canada); M. Roy and R. Vincent (France); R. Jaccard and A.-J. Held (Switzerland); F.A. Carranza, Sr, and R. Erausquin (Argentina); W.W. James, A. Counsell, and E.W. Fish (Great Britain); and A. Leng (Chile) are well known for their important contributions. Probably the most comprehensive book about periodontics published during the first half of the twentieth century was *El Paradencio, Su Patologia y Tratamiento,* which was written by the Uruguayan F.M. Pucci in 1939.

Focal Infection

The concept of systemic diseases originating in dental and oral infections had been mentioned in the Assyrian clay tablets (seventh century BC), by Hippocrates (460-370 BC), in the Babylonian Talmud (third century AD), and by Girolamo Cardano and the German Walter Hermann Ryff during the sixteenth century.[29,52] During the nineteenth century, Benjamin Rush (a famous physician and one of the signers of the American Declaration of Independence) in 1818 and Leonard Koecker in 1828 recognized the role of oral sepsis in rheumatic and other diseases. Later during the nineteenth century, W.D. Miller also mentioned oral infections as the cause of many diseases.[37]

In a paper published in 1900[31] and a decade later in a lecture at McGill University in Montreal, Quebec, Canada,[32] William Hunter (1861-1937), a British physician, indicted dentistry as being the cause of oral sepsis, which in turn caused rheumatic and other chronic diseases. This idea was taken up by Billings, Rosenow, and many others, who advocated the extraction of all teeth with periodontal or periapical infections to prevent systemic diseases. This led to the wholesale extraction of teeth and the removal of the tonsils.

The focal infection theory fell into disrepute when it was found that extractions failed to eliminate or reduce the systemic diseases

to which the infected teeth were supposed to be linked.[15] However, the concept was revisited during the 1990s, this time with a more solid research foundation.

Dental Implants

The replacement of human teeth with implants has been attempted for centuries. Skulls with metal or stone implants have been found in a Gallo-Roman necropolis in France and dated from the second century AD; they were also found in a mandible of Mayan origin dated about 600 AD.[9]

In 1806, the Italian M. Maggiolo attempted to place solid-gold roots in human jaws. Later during the nineteenth century, several other investigators used porcelain and metallic implants. During the first half of the twentieth century, several attempts were made to use elaborate surgical techniques and complicated constructs of gold and other precious metals. Microscopic investigations were begun to address the tissue response to various metals.

In 1939, A.E. Strock of Harvard University started implanting cobalt–chromium (Vitallium) screws into tooth sockets. After World War II, numerous attempts were made with different materials and shapes of implants, including tantalum twisted spiral (Formiggini), Vitallium tree shaped (Lee), acrylic tooth root replica (Hodosh), Vitallium double helical spiral (Chércheve), tantalum tripodal pins (Scialom), tantalum vent-plant and titanium blade (Linkow), and vitreous carbon.[9]

During the 1950s, the Swedish orthopedic surgeon Per-Ingvar Bränemark developed a technique that involved the use of titanium screw-shaped intraosseous implants. This proved to be quite successful, and it was gradually adopted by the dental profession after the 1982 international conference in Toronto, Ontario, Canada. The success and predictability of Bränemark's technique are attributed to the achievement of direct contact between vital bone and the implant surface without intervening soft tissue; this phenomenon was later termed *osseointegration*.[6] Numerous variations of the Bränemark concept were presented by A. Kirsch, G.A. Niznick, A. Schroeder, and others, and they are widely used at present.

After World War II

The United States and Scandinavia took leading roles in basic and clinical periodontal research during and after the 1950s, with major advances made in the fields of experimental pathology, microbiology, immunology, and therapy.

In the United States, five individuals led the efforts to advance our understanding of disease processes and the technical approaches needed to address them: Irving Glickman (1914-1972) (Fig. I.13), Henry M. Goldman (1911-1991), Balint J. Orban (1899-1960) (see Fig. I.8), Sigurd P. Ramfjord (1911-1997), and Helmut A. Zander (1912-1991). In the clinical area, the influence of John Prichard (1907-1990) and Saul Schluger (1908-1990) led to new concepts and new directions in the pursuit of clinical success and excellence.

FIG. I.13 Irving Glickman (1914-1972).

The leading figure of the Scandinavian group was Jens Waerhaug (1907-1980) (Fig. I.14) of Oslo, Norway, whose dissertation entitled *The Gingival Pocket* (1952) and whose lifetime of research opened a new era in the understanding of the biology of the periodontium and the management of periodontal problems.

FIG. I.14 Jens Waerhaug (1907-1980). (From *J Clin Periodontol* 7:534, 1980.)

The next generations centered their attention more on the role of microorganisms and the host response, including its defensive and its destructive aspects. Their contributions, as well as those of their predecessors, are documented in this book.

Several workshops and international conferences have summarized existing knowledge regarding the biologic and clinical aspects of periodontology. Worthy of mention are those that were conducted in 1951, 1966, 1977, 1989, 1996, 1999, and 2008, which were cosponsored and published by the American Academy of Periodontology.

The American Academy of Periodontology, which was founded in 1914 by two female periodontists, Grace Rogers Spalding (1881-1953) and Gillette Hayden (1880-1929), has become the leader in organized periodontics. Its monthly scientific publication, *Journal of Periodontology,* presents all current advances in this discipline. In Europe, the periodontal societies have joined to form the European Federation of Periodontology, which meets regularly at the Europerio meeting. Their official publication is *Journal of Clinical Periodontology.* Other scientific periodontal journals in English include *Journal of Periodontal Research, Periodontology 2000,* and

International Journal of Periodontics and Restorative Dentistry. With regard to journals in other languages, *Journal de Parodontologie* (France), *Periodoncia* (Spain), and *Journal of the Japanese Association of Periodontology* deserve mention.

Periodontal education in the United States also has grown during the second half of the twentieth century, and most dental schools have separate and independent units for teaching and research in this discipline. Periodontics was recognized as a specialty of dentistry by the American Dental Association in 1947. The first university-based programs for the training of specialists in periodontics were begun in several universities (e.g., Columbia, Michigan, Tufts) during the late 1940s; these 1-year programs expanded to 2-year programs about 10 years later. In 1995, the American Academy of Periodontology mandated that all postgraduate periodontal programs increase to a 3-year curriculum because of the increased knowledge in periodontics and the expansion of the scope of periodontics to include the placement of dental implants and the administration of conscious sedation. Currently in the United States, more than 50 periodontal graduate programs are based in universities and hospitals.

The History of This Book

The originator of this book and the author of its first four editions, which were published in 1953, 1958, 1964, and 1972, was Dr. Irving Glickman (see Fig. I.13), professor and chairman of the Department of Periodontology at Tufts University School of Dental Medicine in Boston, Massachusetts.

Dr. Glickman was an outstanding researcher, a superb educator, and a gifted speaker and writer whose concepts shaped periodontal thinking for many years. His style of writing, his ideas, and his philosophy of dental practice can still be found in many areas of this book.

After Dr. Glickman's death in 1972 at age 58, responsibility for continuing this book moved to Dr. Fermin A. Carranza, who had been a student and collaborator of Dr. Glickman. At the time, Dr. Carranza was professor and chairman of periodontics at the School of Dentistry of the University of California, Los Angeles. The

following four editions were published in 1979, 1984, 1990, and 1996 under the guidance of Dr. Carranza, who is now professor emeritus at the University of California, Los Angeles.

In 2002, the task of maintaining the book's tradition of almost half a century changed hands once again. Drs. Michael G. Newman and Henry H. Takei joined Dr. Carranza to take major responsibility for the ninth edition. Starting with the tenth (2006) edition, they were joined by Dr. Perry Klokkevold.

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[†]Deceased.

PART 1

Evidence-Based Practice

OUTLINE

CHAPTER 1

Evidence-Based Decision Making

Jane L. Forrest, Syrene A. Miller, Greg W. Miller, Satheesh Elangovan, Michael G. Newman

CHAPTER OUTLINE

Each day, dental care professionals make decisions about clinical care. It is important that these decisions incorporate the best available scientific evidence to maximize the potential for successful patient care outcomes. It is also important for readers of this book to have the background and skills necessary to evaluate information they read and hear about. These evaluative skills are as important as learning facts and clinical procedures. *The ability to find, discriminate, evaluate, and use information is the most important skill that can be learned as a professional and lifelong learner.* Becoming

excellent at this skill will provide a rewarding and fulfilling professional career.

Background and Definition

Using evidence from the medical literature to answer questions, direct clinical action, and guide practice was pioneered at McMaster University, Ontario, Canada, in the 1980s. As clinical research and the publication of findings increased, so did the need to use the medical literature to guide practice. The traditional clinical problem-solving model based on individual experience or the use of information gained by consulting authorities (colleagues or textbooks) gave way to a new methodology for practice and restructured the way in which more effective clinical problem solving should be conducted. This new methodology was termed *evidence-based medicine* (EBM).[12]

Key Definitions

Evidence: Evidence is considered the synthesis of all valid research that answers a specific question and that, in most cases, distinguishes it from a single research study.[2]

Evidence-based medicine: The integration of the best research evidence with our clinical expertise and our patient's unique values and circumstances.[31]

Evidence-based dentistry: An approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences.[4]

The use of evidence to help guide clinical decisions is not new. However, the following aspects of EBM are new:

- The methods of generating high-quality

evidence, such as randomized controlled trials (RCTs) and other well-designed methods
• The statistical tools for synthesizing and analyzing the evidence (systematic reviews [SRs] and meta-analysis [MA])
• The ways for accessing the evidence (electronic databases) and applying it (evidence-based decision making [EBDM] and practice guidelines)[9,10]

These changes have evolved along with the understanding of what constitutes the evidence and how to minimize sources of bias, quantify the magnitude of benefits and risks, and incorporate patient values.[13] "In other words, evidence-based practice is not just a new term for an old concept and as a result of advances, practitioners need (1) more efficient and effective online searching skills to find relevant evidence and (2) critical appraisal skills to rapidly evaluate and sort out what is valid and useful and what is not."[28]

EBDM is the formalized process and structure for learning and using the skills for identifying, searching for, and interpreting the results of the best scientific evidence, which is considered in conjunction with the clinician's experience and judgment, the patient's preferences and values, and the clinical and patient circumstances when making patient care decisions. Translating the EBDM process into action is based on the abilities and skills identified in Box 1.1.[31]

Box 1.1

Skills and Abilities Needed to Apply an Evidence-Based Decision-Making Process[31]

1. Convert information needs and problems into clinical questions so that they can be answered.

2. Conduct a computerized search with maximum efficiency for finding the best external evidence with which to answer the question.
3. Critically appraise the evidence for its validity and usefulness (clinical applicability).
4. Apply the results of the appraisal, or evidence, in clinical practice.
5. Evaluate the process and your performance.

Principles of Evidence-Based Decision Making

The use of current best evidence does not replace clinical expertise or input from the patient, but rather provides another dimension to the decision-making process,[11,16,19] which is also placed in context with the patient's clinical circumstances (Fig. 1.1). It is this decision-making process that we refer to as "evidence-based decision making" and is not unique to medicine or any specific health discipline; it represents a concise way of referring to the application of evidence to clinical decision making.

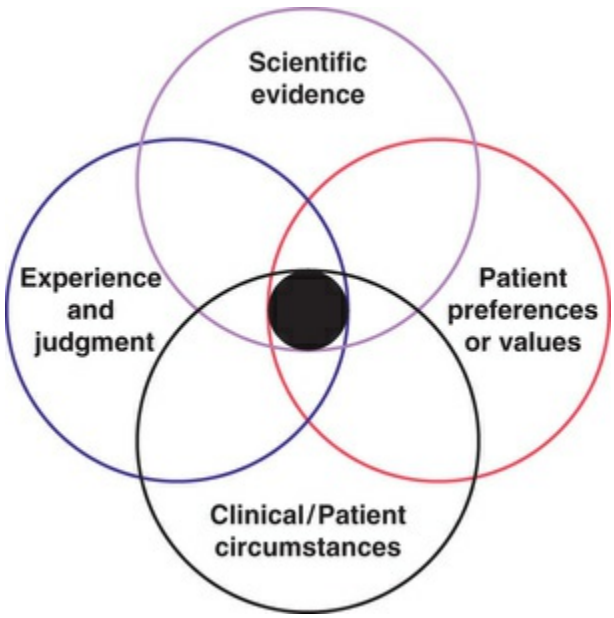


FIG. 1.1 Evidence-based decision making. (Copyright Jane L. Forrest, reprinted with permission.)

EBDM focuses on solving clinical problems and involves two fundamental principles, as follows[13]:

1. Evidence alone is never sufficient to make a clinical decision.
2. Hierarchies of quality and applicability of evidence exist to guide clinical decision making.

EBDM is a structured process that incorporates a formal set of rules for interpreting the results of clinical research and places a lower value on authority or custom. In contrast to EBDM, traditional decision making relies more on intuition, unsystematic clinical experience, and pathophysiologic rationale.[13]

Evidence-Based Dentistry

Since the 1990s, the evidence-based movement has continued to advance and is widely accepted among the health care professions, with some refining the definition to make it more specific to their area of health care. The American Dental Association (ADA) has defined evidence-based dentistry (EBD) as "an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences."[4] They also have established the ADA Center for Evidence-Based Dentistry (ebd.ada.org) to facilitate the integration of EBD into clinical practice.

The ADA's definition is now incorporated in the Accreditation Standards for Dental Education Programs.[3] Dental schools are expected to develop specific core competencies that focus on the need for graduates to become critical thinkers, problem solvers, and consumers of current research findings to enable them to become lifelong learners. The accreditation standards require learning EBDM skills so that graduates are competent in being able to find, evaluate, and incorporate current evidence into their decision making.[3]

Key Fact

PICO

The first step in evidence-based decision making is asking the right question. The key is to frame a question that is simple and at the same time highly specific to the clinical scenario. Dissecting the question you want to ask into its components—problem or population (P), intervention (I), comparison group (C) and outcomes (O)—and then combining them will facilitate a thorough and precise evidence search.[31]

Evidence-Based Decision-Making Process and Skills

The growth of evidence-based practice has been made possible through the development of online scientific databases such as MEDLINE (PubMed) and Internet-based software, along with the use of computers and mobile devices, for example, smart phones, that enable users to quickly access relevant clinical evidence from almost anywhere. This combination of *technology* and *good evidence* allows health care professionals to apply the benefits from clinical research to patient care.[29] EBDM recognizes that clinicians can never be completely current with all conditions, medications, materials, or available products, and it provides a mechanism for assimilating current research findings into everyday practice to answer questions and to stay current with innovations in dentistry. Translating the EBDM process into action is based on the abilities and skills identified in Box 1.1.[31] This is illustrated clearly in a real patient case scenario (management of a patient with trauma-related avulsion and luxation of teeth) that is introduced in Case Scenario 1.1 (Figs. 1.2 and 1.3) and used throughout the chapter.

Case Scenario 1.1

Clinical Application of Evidence-Based Decision Making

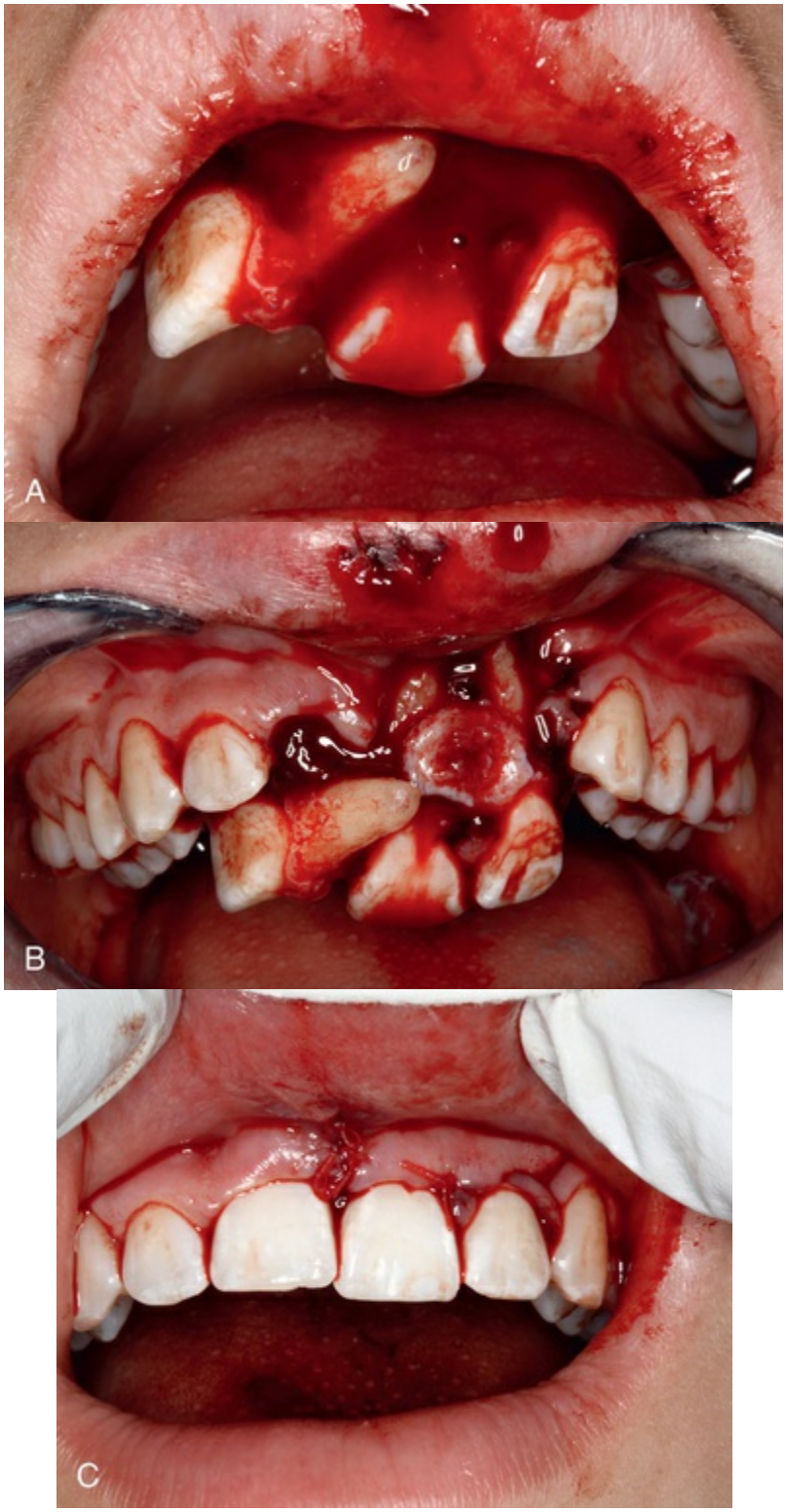
The clinician received a call from the parents of a 13-year-old

female patient who had been struck in the face with a softball. She was being examined by paramedics in a town 30 minutes north of the dental office. The paramedics cleared the patient of any head or neck injury and other medical issues and informed the dentist that dental trauma was her primary injury. The dentist and his assistant met the parents and the patient at the office 45 minutes following the dental trauma. The patient's teeth remained in her mouth following the incident. Fig. 1.2A shows the initial examination of the patient. The preference of the patient and her parents was to "do anything to keep the teeth." After the site was cleaned and irrigated, it was apparent that there was complete avulsion of the maxillary right central incisor from the socket and lateral luxation of the maxillary left central and lateral incisors. In addition, there was alveolar bone fracture partially encasing the roots of the maxillary left central and lateral incisors (Fig. 1.2B.) The clinician replanted the teeth and reapproximated the gingival tissue with sutures (Fig. 1.2C). A stable and accurate ribbond and flowable composite splint were placed (Fig. 1.2D), and a radiograph was taken (Fig. 1.2E).

Radiographic Examination

The radiograph shows reimplantation of maxillary central incisors and left lateral incisor in correct socket location and confirmed proper reapproximation of the alveolar bone that was fractured with maxillary left central and lateral incisors. The stent also is apparent in this radiograph showing the splinting of the displaced teeth.

Due to the difficulty of splint placement and not wanting to risk displacing the teeth or breaking the splint prematurely, the clinician was hesitant to proceed with endodontic treatment until he had access to dependable information. The dentist had two questions regarding the treatment of the patient. He needed to determine the optimal timing of the pulp extirpation and splinting that would result in the best outcome and prognosis for healing. Fig. 1.3 diagrams the decision-making pathway from telephone call to resolution.[24]


A
B
C