Fourth Edition

Implant Restorations

A Step-by-Step Guide

Carl Drago

WILEY Blackwell

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To Wendy – without whom this would not have been
To our next generation "Ad Astra Per Aspera"
Madison, Evie, Aaron, Chandler,
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Foreword

When Dr. Carl Drago asked me if I would consider writing the foreword to this fourth edition, *Implant Restorations: A Step-by-Step Guide*, he explained to me that it would be his honor. Assuredly, it is my personal honor to do this for my very good friend and colleague. I have known Dr. Drago for a long time. It was my very good fortune when he joined the faculty at Marquette University School of Dentistry, as he brought well-founded scholarship, confidence, and competence with him. These professional qualities rarely develop together, but when they do, a unique synergism of art and science is the result. Indeed, Dr. Carl Drago is one of those rare individuals.

Dr. Drago has contributed greatly to the dental profession in terms of discovery and technique. He has authored or coauthored nearly 100 peer-reviewed manuscripts, 7 book chapters, and 7 textbooks. He has written extensively on restorative dentistry, dental implants, laboratory technology, and oral and maxillofacial prosthodontics. Since the early 1990s, he has written almost exclusively about dental implants and associated clinical and laboratory procedures. The first edition of *Implant Restorations: A Step-by-Step Guide* was published in 1997; over 20 years later this textbook is more relevant than ever. Dr. Drago has drawn upon his scientific knowledge and private practice and clinical experiences to compile a how-to guide supported by the best available and contemporary research.

Mentored by some of the best dental practitioners and educators, Dr. Drago undoubtedly heeded some of the advice shared with him. I am certain that giving back to the profession was one of them and his many contributions are exemplified by the vast number of professional presentations given by him and the volume of scientific literature bearing his name. As an academician, Dr. Drago has supported the education and training of dental students and residents for over 40 years. His interactions with residents and patients are exact and considerate, coming from the perspective of an experienced private practitioner, educator, and researcher with a comprehensive understanding of the contemporary literature.

One criterion that is essential before any presentation can be called great, whatever the format, is the ability of the presenter to incrementally introduce knowledge so that even the neophyte can understand the conclusion. In this text, Dr. Drago has done that while taking great care to reproduce his stepwise approach to care found in previous editions and for many clinical scenarios. One of the hallmarks of this fourth edition is a digital approach to restorative care. From chairside scanning to Cone Beam Computerized Tomography, this textbook examines diagnosis and treatment planning options while incorporating the latest technologies. Furthermore, this text prepares the practitioner for an interdisciplinary or a single office approach to implant restorative dentistry.

This textbook reflects the experiences of a greathearted, knowledgeable, and skilled clinician and is presented in a contemporary format that is understandable to restorative dentists at every level. Certainly, writing this foreword was a thrilling endeavor for me. I am very humbled and proud for the privilege.

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Preface

Sometimes your joy is the source of your smile, but sometimes your smile can be the source of your joy.
Thich Nhat Hanh

It is a special honor, unique gift, and distinct privilege to write the preface to this Fourth Edition of *Implant Restorations* by Dr. Carl Drago. I have long been familiar with the wisdom, generosity, and inspiring work of Dr. Carl Drago. In fact, I smiled broadly and deeply when Dr. Drago invited me to write the preface for this important, fourth edition of his pathfinding work. As a teacher and a developmental psychologist with deep appreciation and love for the miracle and magic of how we make our way into and through life – professionally as well as personally – I can attest to this book as a gift of love and expertise. As Dr. Drago's sister, I can attest to the ways it reflects his wisdom and deep commitment to making a difference in this world.

In *Implant Restorations*, Dr. Drago shares with students and colleagues of implant dentistry all that he has learned and discovered about this subject throughout his lifetime of dedication to helping people to feel better about themselves and to feel better about their smiles. I can share with you something of my knowledge of and relationship with Dr. Carl Drago over my own lifetime. Although I do not know the art and science of implant restoration, I do know Dr. Drago. As mentioned, Dr. Carl Drago is my brother. My big brother, in fact. Often, and especially now as I write these words, thinking of Carl and the work that he does with care, with gentleness, and with love makes me smile.

Carl and I are siblings among seven children of a pediatrician – the late Dr. Rosario P. Drago – and a registered nurse – the late Betty Brisgal Drago. Born and raised in The Bronx, New York, Carl and I and our brothers and other sister grew up with medicine and health care as much a part of our everyday conversations and living as were school and sports and childhood friends. From early on, I can remember Carl talking with passion about becoming a dentist one day. It was his goal and his dream. I thought about nursing for a while before settling into the study of education and psychology. As a young girl, I recall asking my big brother Carl why he wanted to be a dentist and then a prosthodontist. As you know, it requires commitment, dedication, much hard work, long study, and sacrifice. My dear brother responded by sharing a version of the same words each time I asked. He knew – deep inside – *how very important people's smiles are* to them and to the world.

Thinking about this now, it strikes me that the face and the smile that we show to the world can mean a lot. We lead with our face. We family with our face. We parent with our face, and our smiles. We teach with our face. We learn and grow and develop in our lives with our face. We might move others with our smile. Our smile is more than warm invitation or elegant display of happiness. Our smile is also reflection of who we are and of how we are feeling. Our smile is light that shines out from within.

Our dad would remind us, on occasion, that the word doctor comes from the Latin docere, which means teacher. Study and learning for our family of origin have always been about not just learning to learn but also about learning to teach and about using what we know and can learn in service to others. As John Dewey reminds us, "Education is not preparation for life, education is life itself." Over the years, I've watched my brother Carl invest as much of himself into research and writing and learning as he invested himself into practice and service and teaching as a prosthodontist. He lives his work. He loves his work. I admire deeply my brother Carl for work he performs that bridges implant research and professional practice. The teaching that Carl offers in dental school programs and the professional development for colleagues that Carl organizes through professional associations are all inspirational to me. Carl inspires me.

I have always learned from my wise and wonderful, visionary brother, Dr. Carl Drago, prosthodontist and teacher. I am deeply grateful to him and to know him. Carl's dedication to this work – and the way his work helps others and makes a difference in the world is testament to his generosity of heart and mind. This book is a gift of care

for others and a gift of love. Carl's work will continue to have a rippling effect in the world and will influence generations of dentists and prosthodontists and those in their care for generations to come. This new edition of *Implant Restorations* will help you, and, in turn, so many more to smile their light from within.

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Introduction to Implant Dentistry

Introduction

The successful long-term clinical use of dental endosseous implants requires some type of biologic attachment of implants to bone. In 1969 Brånemark et al. defined this process as osseointegration (Brånemark et al. 1977). This process has been subsequently studied by numerous researchers around the world and has come to identify the functional stability of the endosseous implant/bone connection (Davies 1998). The histology and biomechanics of osseointegration are beyond the scope of this text; the reader is referred to other sources for further information and increased understanding relative to osseointegration.

Treatment of edentulous or partially edentulous patients with endosseous implants requires a multidisciplinary team approach. This team generally consists of an implant surgeon, restorative dentist, and dental laboratory technician. In some cases, the surgical and restorative portions of the treatments are accomplished by the same clinician. Implant dentistry is a restorative driven service and the ultimate success of implant treatment will be measured, at least in part, by the aesthetic and functional results as perceived by patients. Prosthesis design, whether a single implant-retained crown or full-arch prosthesis, will have a major impact on the number, size, and position of the implant(s) that will be used in a specific treatment plan. Treatment planning for implant dentistry must therefore begin with the restorative phase prior to considering the surgical phases of treatment.

Brånemark and co-workers introduced a two-stage surgical protocol to North America in 1982 (Zarb 1993). Numerous long-term clinical studies have proven the efficacy of titanium endosseous implants (Adell et al. 1981; Friberg et al. 1991; Sullivan et al. 2002; Testori et al. 2002; Ostman et al. 2012; Nicoli et al. 2017). Most clinicians consider osseointegration of dental implants to be predictable and highly effective in solving clinical problems associated with missing teeth (Davarpanah et al. 2002) Alzarea (2016) considered peri-implant soft tissue health as a requisite for successful implant treatment. He evaluated the impact on quality of life of patients treated with dental implants. Alzarea reported that similar inflammatory conditions were present around natural teeth and implant prostheses as suggested by results of mean plaque index, mean bleeding on probing, mean pocket depth, and mean probing attachment level. He reported that this reinforced the importance of periodontal health maintenance prior to and after placement of dental implants. Alzarea concluded that implant prostheses had a significant influence on patient's oral health related quality of life (as depicted by Oral Health Impacts Profile [OHIP]-14); he also concluded that patients' perceptions and expectations may guide clinicians in providing optimal implant services for their patients.

Purpose of Textbook

The purpose of this textbook is to provide clinicians and dental laboratory technicians with a step-by-step approach to the treatment of certain types of edentulous and partially edentulous patients with dental implants. Six types of patient treatments, with multiple implant loading protocols, have been featured. The treatments will be illustrated with emphasis on diagnosis and treatment planning, restorative dentist/implant surgeon communication, laboratory work orders, and restorative treatments, on an appointment-by-appointment basis. The requisite implant components (restorative and laboratory) will be identified for each specific appointment. Laboratory procedures and work orders will also be included.

The biologic and theoretical aspects of osseointegration will not be reviewed. Osseointegration will be defined as clinically immobile implants; absence of peri-implant radiolucencies as assessed by undistorted, accurately positioned radiographs; mean vertical bone loss less than 0.2 mm annually after the first year of occlusal function; and absence of pain, discomfort, and infection (Smith and

Implant Restorations: A Step-by-Step Guide, Fourth Edition. Carl Drago.

Zarb 1989). Clinical verification of osseointegration can sometimes be difficult. Some implants that have been considered successful at the second surgical or impression appointments have subsequently failed prior to or after completion of the prosthetic portion of treatment. Zarb and Schmitt (1990) reported that "late failures" occurred 3.3% of the time in patients with mostly edentulous mandibles. Naert et al. (1992) published a report that contained data from edentulous patients. They reported late failures (7 years post insertion) occurred in 4.9% for mandibular and 10.1% for maxillary cases studied. Late failures are important to clinicians and patients because of the additional expenses and treatments that patients may elect to or need to undergo in replacing prostheses on failed implants.

This text will concentrate on how clinicians may successfully incorporate implant restorative dentistry into their practices. A team approach will be emphasized among members of the implant team: restorative dentists, implant surgeons, dental laboratory technicians, dental assistants, office staff, and treatment coordinators. Appointment sequencing, laboratory work orders, and fee determination for restorative dentists will also be discussed including identification of costs associated with fixed overhead, implant components, laboratory services, and profit margins.

Clinicians have multiple implant systems to choose from. There are similarities and differences among systems including but not limited to macroscopic surface morphology, implant/abutment connections, diameters, thread pitch, and screw hex/morphology. The author and coauthors purchased all the components that were used in this textbook. The principles described in this textbook should be applicable to multiple implant manufacturers.

Conventional Dentistry Versus Implant Dentistry

Predictability of Fixed Prosthodontics

There are numerous goals of prosthodontic treatment including providing aesthetic and functional replacements for missing teeth on a long-term basis. Clinicians would like to attain these goals with restorations that have a predictable prognosis, minimal biologic trauma, and reasonable cost. For a significant number of restorative dentists, there are multiple advantages associated with conventional fixed prosthodontic therapy for natural teeth: familiarity with protocols, techniques, and materials. There are also multiple limitations associated with conventional fixed prosthodontics: tooth preparation and soft tissue retraction, potential pulpal involvement, recurrent caries, and periodontal disease (Figure 1.1). Missing teeth have been predictably replaced with fixed partial dentures for many years. However, increased stresses and demands placed on the abutment teeth, as well as limitations associated with ectopic tooth positions, have been reported. Sailer and others (2007) performed a systematic review that assessed the five-year survival rates and incidences of complications of all-ceramic fixed dental prostheses (FDPs) and compare them with those of metal ceramic FDPs. The five-year survival rate of metal-ceramic FDPs was significantly ($P < 0.0001$) higher (94.4%) than the survival rate of all-ceramic FDPs (88.6%). The frequencies of material fractures (framework and veneering material) were significantly ($P < 0.0001$) higher for all-ceramic FDPs (6.5 and 13.6%) when compared to the rates associated with metal-ceramic FDPs (1.6 and 2.9%). Other technical complications included loss of retention and biological complications (caries and loss of pulp vitality); these were similar for the two types of reconstructions over the five-year observation period.

Figure 1.1 Clinical image of a maxillary anterior fixed dental prosthesis (FDP) with recurrent caries beneath the facial margin of the retainer for the maxillary left lateral incisor. The FDP was 11 years old.

In 1990, more than four million FDPs were placed in the United States (ADA Survey 1994). Comparisons between clinical studies cannot be easily accomplished due to the lack of established parameters (Mazurat 1992). Authors have reported failure rates of FDP's, but the definitions of failures have been inconsistent: recurrent caries, fractured porcelain, broken rigid connectors, loss of periodontal attachment (Schwartz et al. 1970; Reuter and Brose 1984; Walton et al. 1986; Foster 1990; Glantz et al. 1993) (Figure 1.2).

FDPs have documented long-term success. Scurria et al. (1998) performed a meta-analysis of multiple published studies and documented success rates as high as 92% at 10 years and 75% at 15 years. Other authors have recorded failure rates of 30% or more for FPDs at 15–20 years

Figure 1.2 Clinical image of a maxillary fixed, full-arch hybrid prosthesis missing the maxillary central incisor denture teeth. The etiology for this recurring fracture was lack of restorative space.

(Lindquist and Karlsson 1998). Cenci and others (2010) reported that posterior fiber-reinforced fixed partial dentures exhibited acceptable clinical performances up to eight years post insertion (81.8%). A key point that should be recognized from these reports is that for younger patients, FDPs may need to be replaced two to three times during their lifetimes.

Ioannidis and others (2010) investigated the possible influence patients' ages may have on longevity of tooth supported fixed prosthetic restorations. Assessment and selection of studies were conducted in a two-phase procedure, by two independent reviewers, utilizing specific inclusion and exclusion criteria. The minimum mean follow-up time was set at five years. The results of the review demonstrated that increased age of patients should not be considered as a risk factor relative to survival of fixed prostheses. Although most of the studies showed no effect of age on survival of fixed prostheses, the authors concluded that there was some evidence that middle-aged patients may present with higher failure rates.

Miyamoto and others (2007) reported the results of a long-term clinical study where data were collected from 3071 restored teeth, from 1448 compliant patients in a single private practice in Yamagata, Japan. Follow-up times ranged from 15 to 23 years (mean 19.2 years). Every tooth and restoration placed during this time frame was evaluated by one of the authors at each recare visit. Miyamoto and others reported that multisurface restorations had the highest incidence of failures ($P < 0.001$). Abutment teeth for removable dental prostheses (RDPs) had the highest individual failure rates that resulted in extractions. They concluded that restored teeth experienced a higher incidence of failure compared with unrestored teeth. Full crowns and abutments for fixed partial dental prostheses had fewer restorative failures when compared with teeth with complex, multisurface restorations. RDP abutments experienced the highest failure rate.

In a literature review, Priest (1996) reviewed multiple papers to compare the efficacy of implant-retained crowns and conventional FDPs over time. He found that although FDPs were assumed to demonstrate predictable longevity, failure rates included 3% failures over 23 years, to 20% failure rates over three years. Implant longevity, on the other hand, appeared to be more promising and generally displayed narrower ranges of failures: 9% over 3 years to 0% over 6.6 years. Priest cautioned that failure rates for FDPs and implant-retained crowns cannot be easily compared among studies because parameters had not been established and that replacing missing teeth is a complex issue. There are sufficient data for single unit, implant-retained restorations as functional and biologic methods for long-term tooth replacement.

Predictability of Implant Prosthodontics

Wong and others (2018) performed a systematic review to analyze prosthodontic complications, survival, and success of meta-ceramic (MC) and all-ceramic (AC) complete-arch fixed implant dental prostheses (CFIDPs) published between 2000 and 2016. The electronic databases search yielded 1804 relevant titles and abstracts; 11 studies were selected (9 for MC: 2 for AC CFIDPs). The authors reported that the risk of bias in most selected studies was low. Heterogeneity across studies of MC CFIDPs was within an acceptable range but not for the AC CFIDP studies; no meta-analysis was performed for the latter. Regarding MC CFIDPs, most studies recorded 100% survival rate (survival range: 92.4–100%, success range: 47–96.7%), with veneer fracture being the most common complication. Five- and 10-year cumulative complication rates for MC CFIDP veneer fractures were 22.1 and 39.3%, respectively, but with variable confidence intervals. The two studies included for AC CFIDPs reported 100% survival rates but differed in success rates; the one using predominantly monolithic zirconia restorations reported 90.9%, and the one using bilayered zirconia reported 60.4%, with complications attributed to veneer fracture. Wong and others reported that MC and AC CFIDPs veneer fractures were the primary complications. These types of prostheses may require significant maintenance. Other complications were negligible after a mean follow-up period of at least five years.

Mei and others (2017) reported the results of a prospective, longitudinal study that evaluated the clinical and radiographic outcomes of root form, platform switched, microthreaded and sandblasted, large grit, acid etched surface implants for five years. Four patients did not complete the study; 56 implants achieved a 100% survival rate and 98.2% success rate. Three prosthetic complications were reported (success rate for prostheses of 94.6%).

The incidence of peri-implant mucositis was 9.1%; no peri-implantitis was reported. The average marginal bone loss for the mesial implant surfaces was 0.46 ± 0.27 mm after one year; it was 0.48 ± 0.27 mm after five years. The average marginal bone loss on the distal implant surfaces was 0.46 ± 0.32 mm after one year and 0.50 ± 0.35 mm after five years. Mei and others concluded that after five years of loading, the root form, platform-switched, microthreaded, and sandblasted, large grit, acid-etched surface implants demonstrated high survival and success rates, steady crestal bone levels, and excellent long-term clinical outcomes (Figures 1.3 and 1.4).

Economics of Implant Dentistry

One of the major reasons cited by general dentists relative to including or excluding implant dentistry in their practices is the relatively high costs involved in dental implant treatment. Levin (2004) reported that more than 35% of patients referred from general dentists to oral surgeons or periodontists for implant dentistry never actually make the appointment. He recommended that financing should be offered to every implant patient because it is not known which patients will require financing for treatment and which ones will not. Levin considered that offering financing to perspective dental implant patients was no longer an option; it was a necessity. He reported that clients of The Levin Group significantly increased their levels of case acceptance by making financing options available to patients.

Figure 1.3 Anterior view of a patient in centric occlusion with maxillary/mandibular fixed hybrid prostheses three years post insertion.

Figure 1.4 Anterior view of a patient in centric occlusion with implant-retained crown restorations that replaced the maxillary left incisors. The restorations have been in place for approximately six years.

Levin (2005) described a comprehensive approach to dentistry that included four significant parts:

1) Comprehensive examination
2) Tooth-by-tooth exam
3) Cosmetic exam
4) Implant exam

Levin identified implant dentistry for his general practitioner clients as an enormous growth opportunity; he also reported that more than half of general dentists do not restore a single implant in any given year. Implant dentistry not only improves the lives of patients, it also can be a significant profit center for dental practices. Because implant dentistry generally is not covered by dental insurance, Levin stated that implants should be viewed as an opportunity to increase the elective portions of dental practices.

Implant treatment may be divided into treatments relative to partially edentulous and edentulous patients. Partially edentulous patients may warrant treatment involving the replacement of one tooth or they may require replacement of multiple teeth. Periodontal disease may also factor into dental implant treatment planning. It has been the author's personal experience that patients will frequently call for "comparison shopping." A common question is," How much will implants cost?" Patients may also request the costs of a single crown for comparison purposes. It is the responsibility of the dental staff to make sure patients know that to make fair comparisons, patients must compare the costs associated with three-unit FDPs or similar prosthesis to the costs of an implant-retained restoration replacing one tooth. This may sometimes be difficult to explain/inquire of patients during initial phone conversations. (See Tables 1.1 through 1.4.)

Implant dentistry should also be profitable for clinicians and dental laboratory technicians. Initially, as with other new technologies that require acquisition of learned, skilled behaviors, implant restorative dentistry may not be as profitable as other aspects of restorative dentistry. Restorative dentists should expect a learning curve relative to diagnosing, treatment planning, and treatment regarding dental

Table 1.1 Restorative costs/fees/profits associated with a three-unit porcelain fused to metal fixed dental prosthesis (FDP).

Procedures	Expenses	Fee	Profit	Profit/Hr
Clinical		**$4800**	**Fee-Costs**	**Profit/Hr**
Preparation, Impressions, Provisional Restoration	**1.75 hours@$450 per hour $788**		**$4800–$1126-$1912= $2888**	**$2878/2.5 = $1151**
Insertion	**0.75 hour@$450 per hour $338**			
Subtotal (clinic)	**$1126**			
Laboratory				
Casts	**$60**			
Dies	**$50**			
Articulation	**$20**			
FDP	**$656**			
Subtotal (laboratory)	**$1912**			

Table 1.2 Restorative costs/fees/profits associated with a three-unit all ceramic fixed dental prosthesis (FDP).

Procedures	Expenses	Fee	Profit	Profit/Hr
Clinical		**$4800**	**Fee-Costs**	**Profit/Hr**
Preparation, Impressions, Provisional Restoration	**1.75 hours@$450 per hour $788**		**$4800–$1126-$925= $2749**	**$2749/2.5= $1100**
Insertion	**0.75 hour@$450 per hour $338**			
Subtotal	**$1126**			
Laboratory				
Casts	**$60**			
Dies	**$50**			
Articulation	**$20**			
FDP	**$795**			
Subtotal	**$925**			

implants. With practice and reasonable efforts on behalf of the dentist and staff, implant dentistry should become one of the most profitable aspects of general practice.

Prognostic Indicators for Teeth

A question often asked by clinicians and patients relates to the viability and prognosis of maintaining compromised teeth. Even with the advances in implant dentistry since the 1970s, predictability of implants is still not 100%. Therefore, it may still be difficult to recommend extraction of a tooth with a compromised prognosis and suggest replacement of the missing tooth with a dental implant. The American Academy of Periodontology's position paper on dental implants stated that all patients should be informed as to the risks and benefits of implant and alternative treatment prior to implant placement and restoration (AAP Position Paper 2000).

Periodontal Disease

O'Neal and Butler (2002) discussed the clinical and economic factors that clinicians should consider in making

Table 1.3 Restorative costs/fees/profits associated with an implant-retained crown (custom CAD/CAM abutment/zirconia crown).

Procedures	Expenses	Fee	Profit	Profit/Hr
Clinical		**$4800**	**Fee-Costs**	**Profit/Hr**
Impressions	**0.5 hours@$450 per hour $225**		**$2100–$450–1044= $606**	**$2749/2.5= $606**
Insertion	**0.5 hour@$450 per hour $225**			
Subtotal	**$450**			
Laboratory				
Surgical guide	**$125**			
Cast	**$25**			
Soft tissue cast	**$45**			
Articulation	**$20**			
Zirconia layered crown	**$239**			
CAD/CAM abutment	**$385**			
Scan body	**$80**			
Analog	**$40**			
Lab screw	**$20**			
Abutment screw	**$65**			
Subtotal	**$1044**			

Table 1.4 Comparisons of restorative costs, fees, and profits per hour for three-unit fixed dental prosthesis (FPDs) versus single-unit implant-retained crown.

Procedures	Fixed Overhead	Laboratory and Implant Components	Fee	Profit/Hr
Three-Unit FDP (porcelain fused to 50% gold alloy)	$1126	$1922	$4800	$1151
Three-Unit All Ceramic FDP	$1126	$925	$4800	$1100
Implant Restoration	$450	$1044	$2100	$505

In order to accurately compare costs regarding single tooth replacement, implant-retained crowns need to be compared to the costs for three-unit FDPs.

decisions relative to extraction and implant placement versus retention of compromised teeth. They divided the clinical issues into four basic categories:

1) The heavily restored tooth.
2) The furcation-involved tooth.
3) The periodontal-prosthesis patient.
4) Difficult aesthetic cases.

The Heavily Restored Tooth

This type of tooth may have been damaged because of trauma, dental caries, or multiple dental restorations (Figure 1.5). In Figure 1.5, this mandibular molar had been treated endodontically and had moderate horizontal bone loss and recurrent dental caries. The author considered the long-term prognosis for this tooth to be poor if used as the distal abutment for a new three-unit FDP. The treatment choices for this patient included hemisection and distal root amputation, osseous surgery, and a new three-unit FDP. Or, the tooth could be extracted, the socket grafted with bone or a bone substitute, and the extraction site allowed to heal prior to placing an implant and implant restoration (Figure 1.6). Based on the reports of Miyamoto and Priest, the prognosis for the latter choice is better and

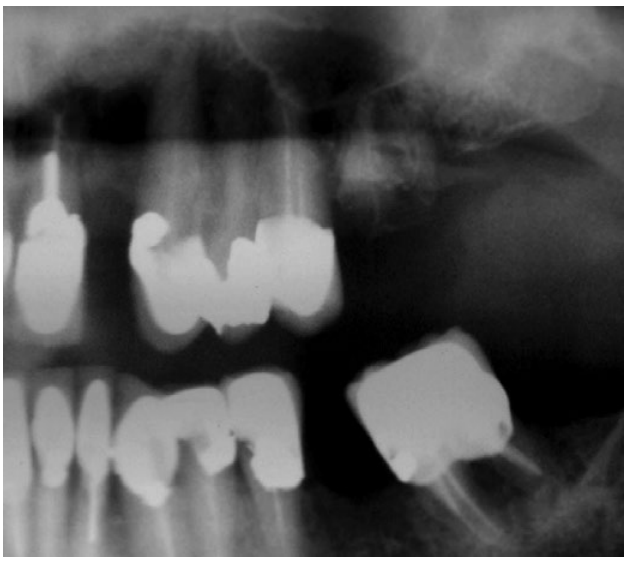

Figure 1.5 Radiograph of mandibular molar that could be potentially used as the distal abutment for a three-unit fixed dental prosthesis (FDP). It had been treated endodontically and restored with a crown. There are recurrent caries beneath the mesial margin.

Figure 1.6 Clinical view of implant-retained crowns that replaced the mandibular right second premolar and first molar.

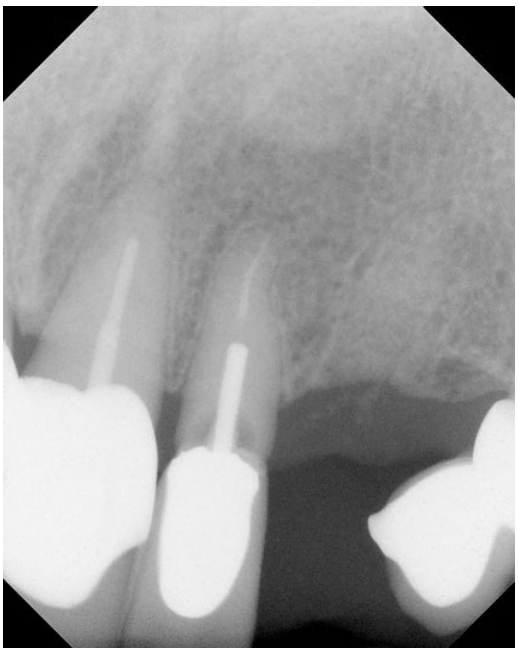

Figure 1.7 Radiograph of a maxillary lateral incisor with previous endodontic therapy. There was an incomplete horizontal root fracture; the post retained the crown restoration.

Figure 1.8 This image was taken approximately three weeks after the patient was involved in a motor vehicle accident. The trauma resulted in avulsion of the maxillary and mandibular left central incisors, significant enamel and dentin fractures of several anterior teeth and devitalization of the remaining maxillary incisors. These teeth were restorable with endodontic and fixed prosthodontic therapy.

may be more conservative long term than the first treatment option.

The clinical condition exemplified by Figure 1.7 is also frequently encountered in clinical practice: an incompletely fractured tooth with previous endodontic therapy where the crown was held in place by a post. Numerous authors have suggested that the axial walls of tooth preparations for endodontically treated teeth should include at least 1 mm of dentin to provide the requisite ferrule effect needed for predictable retention for the crown (Sorenson and Engelman 1990; Fan et al. 1995; Libman and Nicholls 1995). Crown lengthening procedures can be accomplished to obtain greater access to dentin for increased retention of the crown, but this type of surgery is associated with moderate to significant surgical morbidity and accomplished at the expense of the supporting bone Figures 1.7 through 1.9.

Figure 1.9 The patient in Figure 1.8 elected to have the maxillary incisors removed and replaced with dental implants. This image was taken approximately three months post implant placement.

The Furcation-Involved Tooth

Posterior teeth with advanced bone loss are commonly lost or removed. Hirschfeld studied natural teeth over a 22-year period and found that 31.4% of molars and 4.9% of single rooted teeth were lost (Hirschfeld and Wasserman 1978). Decisions to retain or extract posterior teeth generally involve multirooted molars. Both maxillary and mandibular molar teeth exhibit concavities associated with multiple roots. The anatomy may also be compromised with recurrent caries and lateral canals. In Figure 1.10, the mandibular right first molar had previous endodontic therapy, advanced horizontal bone loss around both roots and in the furcation, mobility, and was uncomfortable for the patient. The patient's chief complaint related to the discomfort that she was feeling anytime she attempted to chew on the right side. She did not want to have this tooth extracted. Even with a root resection, this tooth had a poor prognosis as an abutment for an FDP. A more appropriate choice would be extraction, grafting, and placement of one implant to replace the missing molar.

Figure 1.10 Radiograph of mandibular right posterior segment that demonstrates advanced bone loss around the first molar and Class III furcations. This tooth was a poor candidate for root resection and future use as an abutment for a three-unit fixed dental prosthesis (FDP).

The most common causes of failure in posterior, furcation-involved teeth have been reported to be recurrent caries and endodontic failure (Buhler 1994). When clinical success is likely, root resection procedures can be clinically acceptable with a reasonable long-term prognosis. In Figures 1.11 through 1.13, compromised mandibular molars were treated with endodontic therapy, posts, root resections, and a fixed periodontal splint. This radiograph was taken 15 years after the prosthesis was inserted.

Figure 1.11 Radiograph after endodontic therapy for the mandibular right first and second molars prior to resection of the second molar's mesial root and hemisection of the mandibular first molar's roots.

Figure 1.12 Clinical image with the mandibular fixed dental prosthesis (FDP) cemented in place of the patient in Figure 1.11.

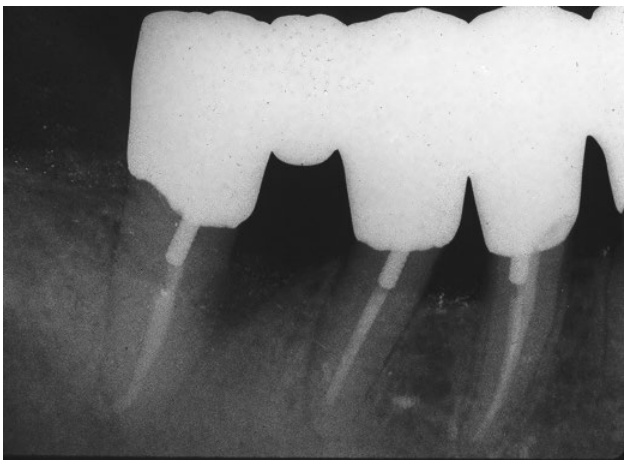

Figure 1.13 Radiograph of the patient in Figure 1.11 at fixed dental prosthesis (FDP) try in appointment; this prosthesis has remained in place, without recurrent caries or other issues for 21 years.

The Periodontal Prosthesis Patient

Dentistry has experienced significant advances in treatment alternatives for the severely compromised dentition. In the 1960s and 1970s these advances resulted in salvaging many teeth that had previously been extracted (Yalisove and Dietz 1977). Conventional fixed and removable prosthodontic treatments were not applicable to treat severely compromised dentitions; especially in cases where there were multiple missing teeth and moderate to advanced bone loss. Amsterdam defined the sophisticated dental therapy to treat such patients as periodontal prosthesis (Amsterdam 1974). Periodontal prosthesis is the treatment required to stabilize and retain dentitions that have been weakened by the loss of alveolar bone and multiple teeth. In the past, periodontal prostheses were the primary means to treat these debilitated dentitions. Today the use of dental implants has decreased the frequency for these complex patients to be treated with periodontal prosthesis (Nevins 1993).

This patient presented to the author in 1988 with multiple missing teeth, an end-to-end dental occlusion, moderate to advanced bone loss, and a severe gag reflex (Figures 1.14 and 1.15). The diagnostic phase of treatment consisted of thorough radiographic and physical examinations. The treatment plan that was developed and agreed upon with the patient called for a diagnostic articulator mounting (Figure 1.16), diagnostic wax patterns (Figure 1.17), extraction of several hopeless teeth, periodontal osseous and soft tissue surgery, and a maxillary periodontal prosthesis (Figures 1.18–1.20). The mandibular incisal plane was recontoured in conjunction with the maxillary reconstruction.

Figure 1.14 Preoperative anterior view of a patient with compromised maxillary and mandibular dentitions.

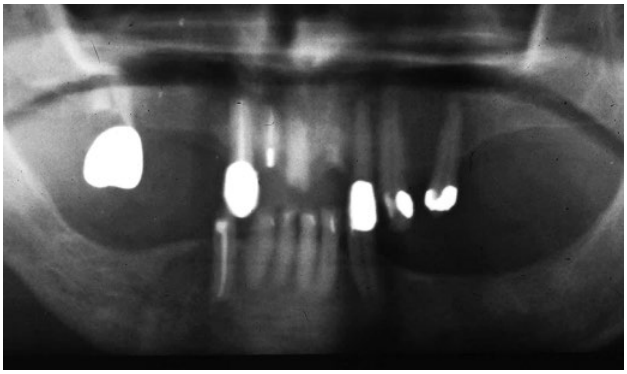

Figure 1.15 Preoperative panoramic radiograph of the patient in Figure 1.14 that demonstrated moderate horizontal bone loss, recurrent caries, and multiple missing teeth.

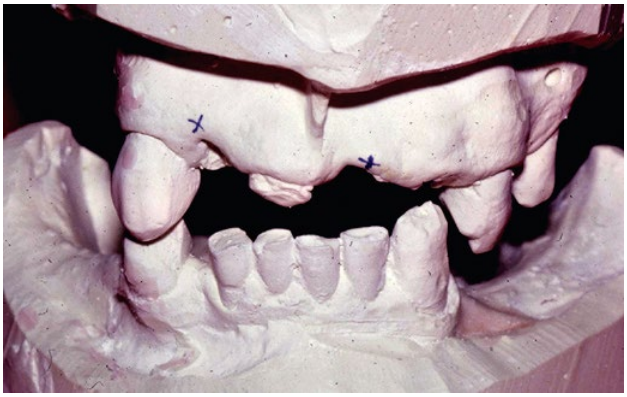

Figure 1.16 Preoperative diagnostic articulator mounting at the existing vertical dimension of occlusion for the patient in Figures 1.14 and 1.15.

The patient functioned comfortably for several years and then presented with a problem with the maxillary right canine eight years post insertion (Figure 1.21). This tooth was diagnosed as having a combined periodontal/endodontic lesion. The periodontal prosthesis was tapped

Figure 1.17 Diagnostic wax patterns for the patient in Figures 1.14 through 1.16; incisal plane of the mandibular teeth was modified, and the maxillary incisal plane was moved incisal per patient request.

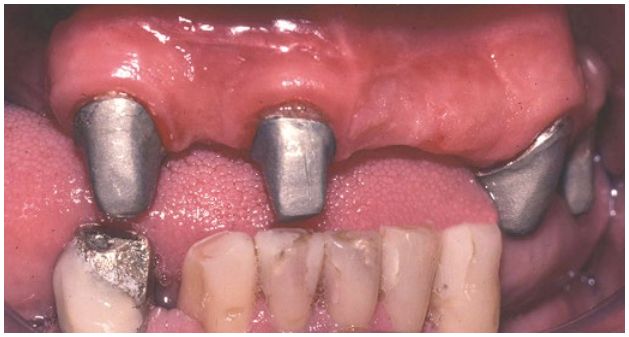

Figure 1.18 Clinical anterior view with the maxillary copings of the periodontal prosthesis in place.

Figure 1.19 Periodontal prosthesis for the patient in Figures 1.14 through 1.18 in place at insertion. This prosthesis was cemented to the copings with temporary cement.

off and the cuspid was extracted. The periodontal prosthesis was recemented and remained in place for an additional 8 years (16 years post insertion; the last recare appointment). Note the amount of residual ridge resorption gingival to the cuspid and lateral incisor pontics (Figure 1.22).

If this patient presented to a dentist today, this treatment certainly should be offered as a treatment alternative. The morbidity associated with periodontal surgery, endodontic

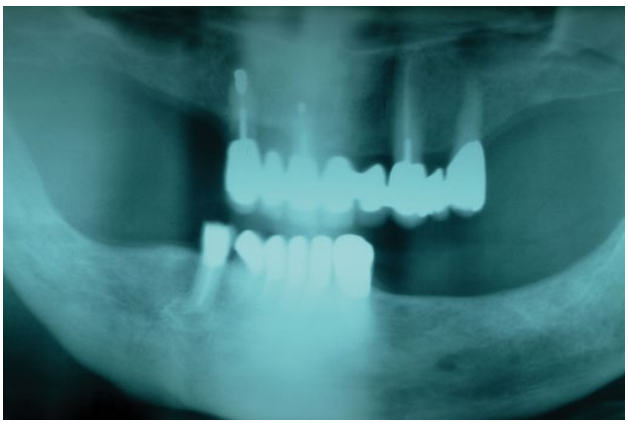

Figure 1.20 Postoperative panoramic radiograph of the patient in Figure 1.19. This patient could not tolerate a mandibular removable dental prosthesis (RDP); the mandibular posterior teeth were not replaced.

Figure 1.21 Clinical anterior view of the patient in Figures 1.14 through 1.20, eight years post insertion. The maxillary right cuspid was lost secondary to a combined periodontal/endodontic lesion. The periodontal prosthesis was removed, and the retainer #6 was filled with composite resin. The intaglio surface of the pontic was contoured for use as an ovoid pontic; the periodontal prosthesis was reinserted.

surgery, and the complexities associated with the fixed prosthodontic treatment probably would outweigh the morbidities involved in extraction of the teeth, grafting as needed, placement of implants, and implant prosthetic treatment with either fixed or removable prosthodontics. Implant placement and immediate occlusal function also could be considered. The net, long-term results with fixed implant-retained restorations would likely be more predictable on a long-term basis than the results that could be obtained with periodontal prosthesis (Figures 1.23–1.25).

Difficult Aesthetic Cases

Replacement of anterior teeth with dental implants is probably one of the greatest challenges that a dental implant team will face. There are numerous factors to consider in

Figure 1.22 Clinical left lateral view 8 years post extraction of maxillary right cuspid (16 years post insertion of the original prosthesis). Note the amount of alveolar ridge resorption gingival to the cuspid and lateral incisor pontics.

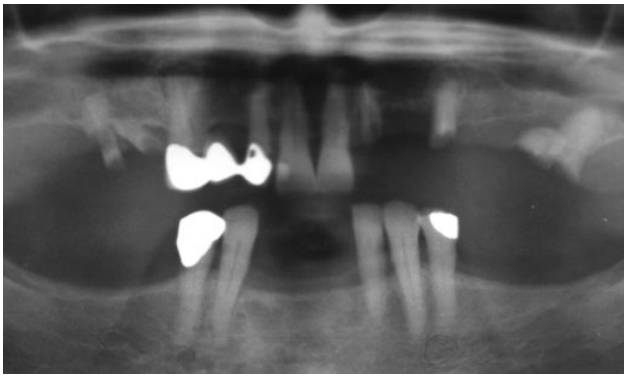

Figure 1.23 Preoperative panoramic radiograph of a patient that demonstrated severe dental caries, moderate horizontal bone loss and multiple missing teeth.

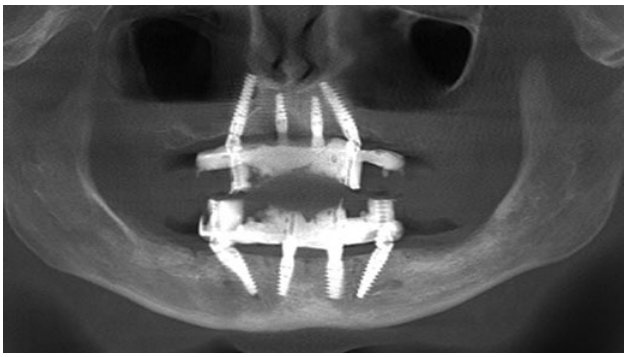

Figure 1.24 Postoperative panoramic radiograph of the patient in Figure 1.23 after removal of the failing dentition, followed by maxillary and mandibular implant placement and immediate occlusal loading of interim maxillary and mandibular prostheses.

Figure 1.25 Clinical view of patient from Figures 1.23 and 1.24, smiling with the definitive maxillary and mandibular implant prostheses in place.

order to fabricate aesthetic, long-term, functional restorations: bone quality and bone quantity, gingival symmetry, periodontal biotype, three-dimensional orientation of the edentulous space and adjacent teeth, presence or absence of inter dental papillae, location of the lip during speaking, smiling and at rest. Dentists and patients have come to expect excellent aesthetic and functional results in the anterior regions of the mouth (Chang et al. 1999).

However, implant-retained restorations may not always be the most appropriate treatment option. Fixed and removable partial dentures may still be viable options for patients who need to replace anterior teeth (Figure 1.26). In the case of multiple missing teeth, anatomical limitations, and inadequate bone volume, a fixed partial denture

Figure 1.26 Clinical view of a patient missing a maxillary right lateral incisor who had inadequate bone volume for implant placement and did not want to have bone grafting accomplished for an implant-retained crown. The missing lateral incisor was replaced with a three-unit fixed dental prosthesis (FDP); pink gingival porcelain was used on the cervical portion of the pontic to compensate for the loss of alveolar bone and soft tissues.

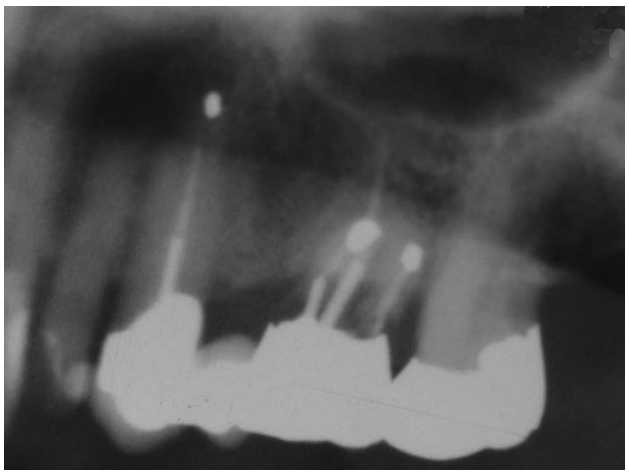

Figure 1.27 Radiograph of a patient with a nonrestorable maxillary left first molar, pneumatized maxillary sinus, and inadequate bone volume for implant placement.

Figure 1.29 This is the same patient in Figure 1.28. The posterior teeth were restored with crowns; the maxillary anterior teeth were replaced with a new removable dental prosthesis (RDP) that provided improved lip support and incisal display of the teeth.

may be more appropriate if bone grafting is needed (Figure 1.27). In the case of multiple missing teeth and significant alveolar ridge resorption, an RDP with a labial acrylic resin flange may be the treatment of choice in order to provide patients with the requisite lip support (Figures 1.28 and 1.29).

For aesthetic restorations, implants must be placed in optimal positions relative to the proposed locations of the teeth, not relative to the available bone (Garber 1995). Implant placement must also be viewed in three dimensions: mesio/distal, facial/lingual, and occlusal/cervical. Deficient sites need to be augmented with bone and/or soft tissue as needed to ensure optimal implant placement. In this instance, there appeared to be adequate bone volume for implant placement on the periapical radiograph (Figure 1.30). At the surgical appointment, the bone was noted to be deficient vertically; the implant surgeon chose to place the implants despite the vertical deficiency (Figure 1.31). In spite of multiple issues associated with implant placement, location, and lack of keratinized tissues around the premolar implant, this patient has adapted to the restorations and maintained them 15 years post implant insertion (Figure 1.32).

Classification of Ridge Defects

Restoration of edentulous spaces in the aesthetic zone with dental implants should probably not be undertaken by surgeons and restorative dentists with limited implant experience (Weisgold et al. 1997). Thorough preoperative

Figure 1.28 This patient had lost her maxillary anterior teeth 10 years before this photograph. The anterior and posterior occlusal planes were at different vertical heights. There was inadequate lip support with the existing removable dental prosthesis (RDP) denture flange.

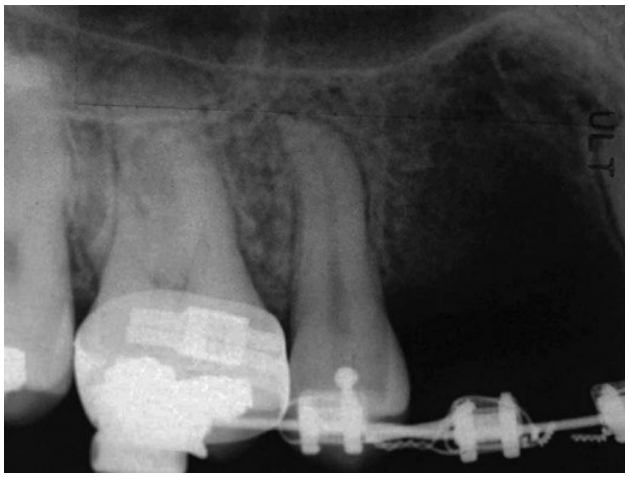

Figure 1.30 Preoperative periapical radiograph of a maxillary right quadrant that demonstrated adequate bone volume (in two dimensions) for implant placement to replace the missing maxillary right first premolar and cuspid teeth.

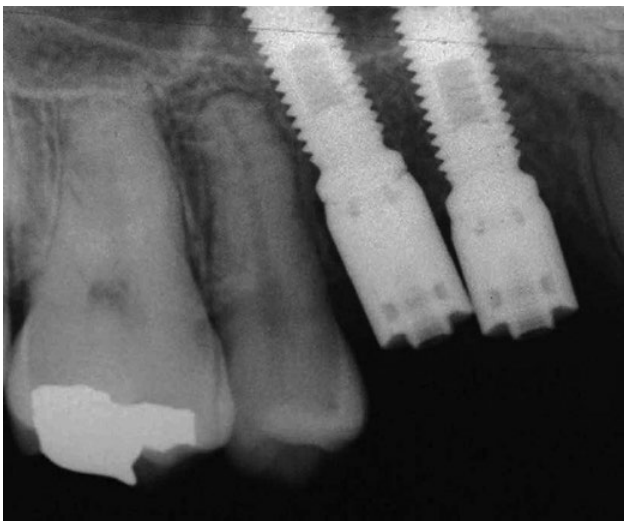

Figure 1.31 This is the same patient as in Figure 1.30. Postoperative radiograph identified that the two implants were placed too close together and superior relative to the cemento/enamel junction of the adjacent teeth.

Figure 1.32 Clinical view of the patient in Figures 1.30 and 1.31. Note the contours, lack of keratinized tissue, and quality of the peri-implant soft tissues around the implant restorations. The long term prognosis for these restorations and implants was poor.

diagnostic workups are especially warranted prior to embarking on treatment in the anterior maxillae (Hess et al. 1998). Ridge deformities have been classified into three types: Class I-loss of buccal/lingual width; Class II-loss of vertical height; Class III-combination of Class I and II (Seibert 1983). Bone regeneration therapy is now well

Figure 1.33 Preoperative occlusal view of a maxillary diagnostic cast that demonstrated a Class I horizontal ridge defect.

Figure 1.34 10-week postoperative clinical view of the patient in Figure 1.33 that demonstrated the increased buccal/lingual width of the edentulous ridge secondary to grafting with demineralized, freeze-dried bone and placement of a resorbable membrane.

accepted by dentistry. The horizontal Class I defect was predictable to treat (Figures 1.33 and 1.34). However, augmentation procedures will likely add time to the overall time frame of implant treatment, as well as adding expense for the treatment.

This RDP did not restore the surgical or restorative volumes required for aesthetic replacement of the missing maxillary central incisor (Figure 1.35). The defect was significant in both vertical and horizontal planes. In this case, the ill-fitting partial denture was diagnostic for the surgeon by giving him/her an idea as to the volume of material required to eliminate the defect (Figure 1.36). A surgical guide would still be beneficial for the surgeon, even if an implant cannot be placed at the time of bone grafting (Figure 1.37).

This 28-year-old patient presented with internal and external resorption of the maxillary left incisors (Figures 1.38 and 1.39). The patient was presented with several treatment options including endodontic treatment for both teeth. Patel and others (2018) reviewed external cervical resorption

Figure 1.35 Clinical view of a transitional removable dental prosthesis (RDP) that did not replace the missing hard and soft tissues associated with the missing maxillary left central incisor.

Figure 1.36 Clinical occlusal view that demonstrated the significant horizontal component of a defect that would have to be addressed prior to or during implant placement.

Figure 1.37 Surgical guide on a diagnostic cast that would be appropriate for the implant surgeon to use during the augmentation portion of the surgical treatment.

Figure 1.38 Clinical image of a patient with splinted crowns that restored the maxillary incisors. They were splinted together to camouflage the missing interdental papillae between the incisors.

Figure 1.39 Periapical radiograph of the teeth in Figure 1.38. The central incisor had external resorption and a periapical radiolucency; the lateral incisor had internal resorption. Both teeth were scheduled for removal in anticipation of dental implant placement and restoration.

(ECR) and its management. They reported that effective management of ECR depended on accurate assessment of the true nature and accessibility of ECR. In cases where ECR was supracrestal, superficial, and with limited circumferential spread around the tooth, a surgical repair without root canal treatment was preferred. With more extensive ECR lesions, Patel and others advised that vital pulp therapy or root canal treatment may be indicated. Internal repair was indicated where there was limited resorptive damage to the external aspect of the tooth and/or where an

external (surgical) approach was not possible due to the inaccessible nature of subcrestal ECR. In these cases, root canal treatment was needed. Intentional reimplantation was indicated in cases where surgical or internal approach was not practical. Atraumatic extractions and short amounts of time where the extracted tooth was out of the mouth, followed by two weeks splinting were important prognostic factors. Patel and others also concluded that extraction of the affected tooth may be the only option in untreatable cases where aesthetic, functional, and/or symptomatic issues were involved. The long-term prognosis for this specific case was determined to be poor.

The maxillary left incisors were removed atraumatically and grafted with freeze-dried, demineralized bone. An Essix retainer was inserted to avoid pressure on the surgical site (Figures 1.40 and 1.41). Due to limited space available for implant placement and the patient's low lip line, it was felt that a computer-guided surgical approach would be appropriate. A computer-generated surgical guide was fabricated from a Cone Beam CT (CBCT) scan (Figures 1.42 through 1.44). The implants were placed uneventfully with a two-stage surgical protocol (Figure 1.45). Computer-assisted design/computer-assisted machining (CAD/CAM) abutments were designed, milled, and inserted prior to insertion of the definitive all ceramic crown restorations (Figures 1.46 and 1.47).

Treatment Prognosis for the Dentition

Diagnosis and treatment planning for patients with compromised dentitions can be one of the more daunting challenges facing dental practitioners. A process should be developed that assists practitioners in formulating treatment plans that are evidence based, predictable, and as practical as possible. Accurate diagnoses are critical for treatment success and need to be identified relative to periodontal disease, occlusion (skeletal and dental), and other anatomical considerations (maxillary sinus, inferior alveolar canal, etc.).

Figure 1.41 An Essix retainer was made as the interim restoration to minimize pressure on the surgical site for the patient in Figures 1.38 through 1.40.

Figure 1.42 Occlusal view of the maxillary printed model for the patient in Figures 1.38 through 1.41. The model was made from the CBCT scan taken approximately five months after the surgery.

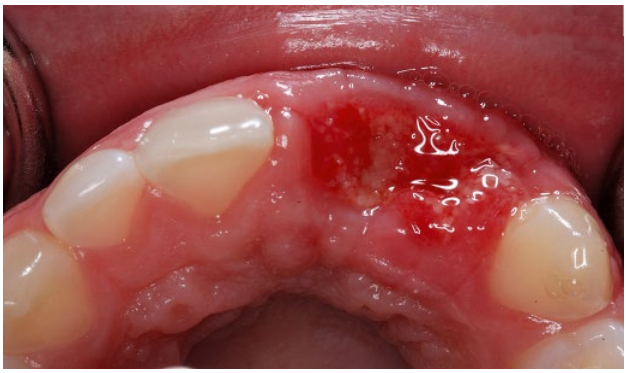

Figure 1.40 Clinical occlusal image one week post extraction, grafting, membrane placement, and primary closure of the patient in Figures 1.38 and 1.39.

Figure 1.43 Laboratory image of the computer-generated surgical guide for the patient in Figures 1.38 through 1.42.

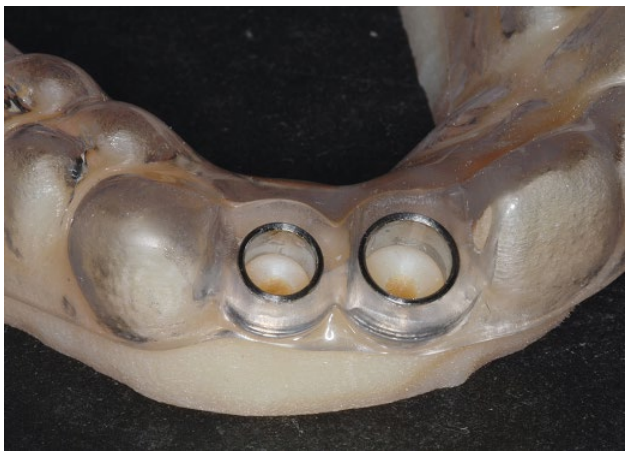

Figure 1.44 Laboratory image of the computer-generated surgical guide in place on the printed maxillary model.

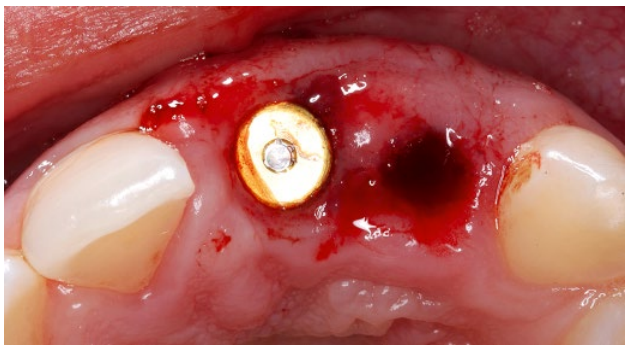

Figure 1.45 Occlusal image of the patient in Figures 1.38 through 1.44 after placement of the dental implant in the central incisor site; a two-stage surgical protocol was used.

Patients who present with moderate to advanced periodontitis have several generic treatment options available to them: periodontal surgery with grafting, membranes, antimicrobial therapy, etc.; selective extraction and replacement with removable or fixed prostheses supported by natural teeth; selective extraction and replacement with removable or fixed prostheses supported by dental implants; or full-arch extractions and prosthetic replacement (Figure 1.48).

Figure 1.47 Clinical image of the patient in Figures 1.38 through 1.46 smiling one week post insertion of the abutments and crowns.

An argument could be made for the patient in Figure 1.48 that with selective extractions, periodontal therapy, and fixed/removable prosthodontic treatment, the dentition could be salvaged and maintained for a number of years. However, what would the morbidity and expense be for the required treatments and how long should the patient and clinician reasonably expect the reconstruction to last? Wang et al. (1994) studied the influence of furcation involvement on tooth loss over a period of eight years. They reported that with and without furcation involvement, 23 and 13% respectively were lost after eight years. Other authors have reported similar findings (Hirschfeld and Wasserman 1978; McFall 1982; Goldman et al. 1986).

Ravald and Johansson reported on the results of tooth loss in periodontally treated patients over 11–14 years.

Figure 1.46 CAD/CAM titanium abutments were designed and milled for use as custom abutments for cement-retained implant crowns.

Figure 1.48 Preoperative clinical view of a patient with advanced periodontitis and a significant dental malocclusion who did not wish to maintain his dentition.

Sixty-four patients participated in the follow-up study. Reasons for tooth loss were identified through dental records, radiographs, and clinical photos. They identified factors contributing to tooth loss, via a logistic multilevel regression analysis. During the course of the study, 211 teeth were lost. They identified the main reason for tooth loss was recurring periodontal disease (n = 153). Root caries and endodontic complications were responsible for 28 and 17 lost teeth, respectively. Thirteen teeth were lost for other reasons. Ravald and Johansson also reported that the number of teeth ($P = 0.05$) and prevalence of probing pocket depths, 4–6 mm ($P = 0.01$) at baseline, smoking ($P = 0.01$) and the number of recare visits with dental hygienists ($P = 0.03$) during the maintenance phase of therapy significantly contributed to the variations noted for tooth loss. They concluded that previously treated patients at their periodontal specialty office continued to lose teeth despite maintenance treatments at general practitioner offices with professional dental hygienists. They also concluded that the main reason for tooth loss in their study was recurring periodontal disease. They also noted that tooth loss was significantly more prevalent among smokers than nonsmokers and concluded that tooth loss risk factors included smoking, low numbers of teeth present preoperatively, and prevalence of 4–6 mm periodontal pockets.

Findings such as these may make it difficult for clinicians to recommend intensive periodontal and fixed prosthodontic therapy to patients where the support for the reconstruction is dependent on compromised teeth.

In another case of a debilitated dentition, a patient presented three years post periodontal surgery (Figure 1.49 and 1.50). This patient reported that she spent approximately 20 minutes per day brushing, flossing, and rubber tipping in and around all of her teeth

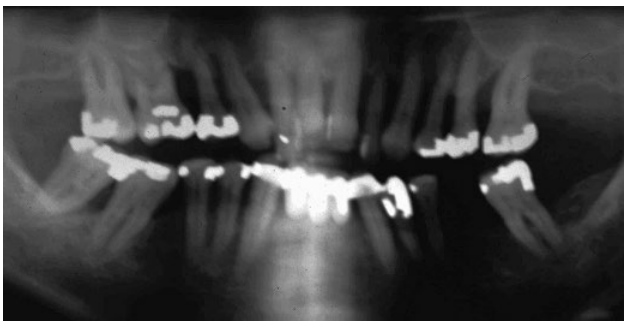

Figure 1.50 Panoramic radiograph corresponding to Figure 1.49. Horizontal bone levels were stable over the previous three years. However, the patient was dissatisfied with her esthetic and functional results.

and gingival tissues. She reported that the teeth were still sensitive and prone to food impaction and she considered her smile to be quite unattractive. One of the treatment options that was discussed included selective extractions of the most compromised teeth and replacement of the missing teeth with fixed or removable prostheses. The patient did not wish to spend any more time or money on maintaining her teeth and opted to have the teeth extracted and replaced with complete dentures. She healed uneventfully from the extractions but had great difficulty managing the mandibular complete denture. After further consultation, she proceeded with implant placement and reconstruction with a maxillary complete denture and mandibular fixed hybrid prosthesis (Figure 1.51).

Morrow and Brewer (1980) presented a treatment planning concept for debilitated dentitions prior to the advent of implant dentistry as we know it today. They considered removable overdentures to be indicated if four or fewer

Figure 1.49 Preoperative clinical view of a patient three years post periodontal surgery. Note the relatively long clinical crowns, malocclusion, and crowding. These conditions led to food impaction in and around multiple teeth and poor dental aesthetics.

Figure 1.51 Postoperative clinical view of patient in 1.50 with definitive maxillary complete denture and mandibular fixed hybrid implant prosthesis in place circa 1989. Even though she was edentulous, she reported that she was quite pleased with her new aesthetic and functional prostheses.

Figure 1.52 Clinical view of a patient eight years post insertion of a maxillary overdenture supported by two overdenture abutment teeth. The abutment teeth were restored with copings. This patient lost a minimal amount of bone in the anterior maxillae secondary to retention of these two abutment teeth.

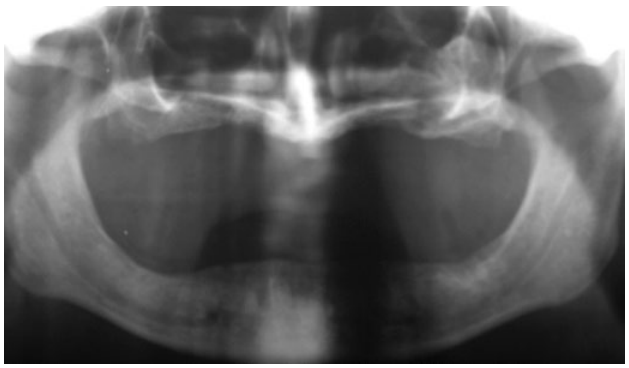

Figure 1.53 Panoramic radiograph of a patient who lost his maxillary teeth 25 years prior to this radiograph. The mandibular teeth were lost two years prior to this radiograph. Note the significant bone resorption that has occurred in the maxillae compared to how little bone has resorbed in the mandible.

retainable teeth remained in a dental arch. If more than four viable teeth remained, they considered fixed or removable partial prosthodontic treatment for potential long-term treatment solutions. They stressed that having four teeth was not immutable and that treatment planning required flexibility as to the number and position of the abutments for overdentures. Morrow and Brewer recognized that overdentures were not appropriate for every patient, but they also stated that there were few situations where complete dentures were preferable to overdentures, as they routinely saw the results of long-term edentulism and the difficulties associated with adaptation to complete dentures (Figures 1.52 and 1.53).

Summary

In order to provide state-of-the-art treatment for patients, clinicians must constantly update their knowledge and clinical skills. Clinicians are responsible for gathering the physical and radiographic data required for accurate diagnoses of patients' conditions. They are also required to provide treatment options to patients that are evidence based and predictable. Financial considerations also need to be considered by patients and clinicians. Treatment planning will become less problematic for clinicians who keep their knowledge and skills current, perform comprehensive examinations, and provide evidence-based treatment options. Patients will also benefit by having treatments performed that are best for them at the time decisions need to be made.

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