Minimally Invasive Dental Implant Surgery
Minimally Invasive Dental Implant Surgery

Edited by

Daniel R. Cullum DDS
Oral and Maxillofacial Surgeon
Private Practice
Coeur d’Alene, ID, USA
Guest Lecturer
Loma Linda University Department of OMS
Loma Linda, CA, USA
Guest Lecturer
UCLA Department of OMS
Los Angeles, CA, USA

Douglas Deporter DDS, Dipl Perio, PhD
Discipline of Periodontics
Faculty of Dentistry
University of Toronto
Toronto, ON, Canada

WILEY Blackwell
Contents

Contributors, vii
Memorial, viii
Foreword, ix
Preface, x
Acknowledgments, xi
Copyright note, xii

Section I: Technology, Diagnosis, and Treatment Planning

1. Diagnosis and Treatment Planning for Minimally Invasive Dental Implant Treatment, 3
   Jean-Francois Bedard & Daniel R. Cullum

2. Diagnostic Imaging for Patient Evaluation and Minimally Invasive Treatment Planning, 28
   Scott D. Ganz

3. Risk Assessment and Avoiding Complications, 51
   David Dara Yarmand, Douglas Deporter, & Daniel R. Cullum

4. The Provisional Restoration: A Diagnostic, Functional, and Esthetic Template, 66
   Aldo Leopardi & Daniel R. Cullum

Section II: Technology and Surgery

5. Extraction Site Management for Ridge Preservation and Implant Site Development, 89
   Barry Bartee & Daniel R. Cullum

6. Engineering Biologic Width and Tissue Levels with Implant and Abutment Surface Preparation, 107
   Myron Nevins, Cary A. Shapoff, Khalid Al Hezaimi, & David M. Kim

7. Recombinant Human Bone Morphogenetic Protein-2 or Recombinant Human Platelet-Derived Growth Factor BB in Extraction Site Preservation and Bone Augmentation, 119
   Craig M. Misch, Marc L. Nevins, & Jason A. Boch

8. Periodontal and Peri-implant Soft Tissue Surgery, 137
   Giles Horrocks, Christine Cole, & Daniel R. Cullum

   Gary Orentlicher, Andrew Horowitz, & Marcus Abboud

Section III: Optimizing Anatomical Limits with Short, Narrow and Angled Implants

10. Short Implants, 193
    Douglas Deporter

11. Narrow Implants, 208
    Joerg Neugebauer, Douglas Deporter, & Daniel R. Cullum

12. Minimally Invasive Complete Arch Treatment: The Versatility of Angled Implants, 219
    Ole T. Jensen & Daniel R. Cullum

    Tomaso Vercellotti & Claudio Stacchi

Section IV: Implant Site Development

    Bach T. Le & Sze Wing Cynthia Au Young

15. Trans-Alveolar Sinus Elevation and Contiguous Sinus Floor Elevation, 251
    Daniel R. Cullum & Douglas Deporter

16. Ridge Expansion, 285
    Daniel R. Cullum

17. Ridge Expansion Combined with Trans-Alveolar Sinus Elevation, 311
    Daniel R. Cullum
Section V: Immediate Implant Reconstruction

   Daniel R. Cullum & Douglas Deporter

19. Immediate Esthetic Zone Tooth Replacement, 367
   Daniel R. Cullum & Howard Park

Section VI: Comprehensive Applications of Minimally Invasive Surgery

20. Skeletal Anchorage and Orthodontics in Implant Site Development, 387
    Michael P. Chaffee & Daniel R. Cullum

21. Minimally Invasive Comprehensive Treatment: Case Studies, 412
    Daniel R. Cullum & Earl Ness

Index, 443
Contributors

Marcus Abboud, DMD
Associate Professor and Founding Chair
Department of Prosthodontics and Digital Technology
Stony Brook University
Stony Brook, NY, USA

Khalid Al Hezaimi, BDS, MSc
Research Chair for Growth Factors and Bone Regeneration
King Saud University
Riyadh, Saudi Arabia

Sze Wing Cynthia Au Yeung, BDS, DDS, MD
Assistant Professor
Division of Oral & Maxillofacial Surgery
The Herman Ostrow School of Dentistry of USC
Los Angeles County/USC Medical Center
Los Angeles, CA, USA;
Private Practice
Los Angeles, CA, USA

Barry Bartee, DDS, MD
Osteogenics Biomedical, Inc.
Private Practice
Restorative and Implant Dentistry
Lubbock, TX, USA

Jean-Francois Bedard, DMD
(deceased)
Private Practice, Prosthodontics
Denver, CO, USA

Jason A. Boch, DMD, DMSc
Instructor, Harvard School of Dental Medicine
Department of Oral Medicine, Infection, and Immunity
Boston, MA, USA;
Private Practice
Wayland, MA, USA

Michael P. Chaffee, DDS, MS
Orthodontist, Private Practice
Coeur d’Alene, ID, USA

Christine Cole, DDS, MHS
Private Practice, Periodontics
Boulder, CO, USA

Daniel R. Cullum, DDS
Private Practice, Oral/Maxillofacial Surgery
Implants Northwest
Coeur d’Alene, ID, USA;
Guest Lecturer
Loma Linda University Department of OMS
Loma Linda, CA
Guest Lecturer
UCLA Department of OMS
Los Angeles, CA, USA

Douglas Deporter, DDS, Dipl Perio, PhD
Discipline of Periodontics
Faculty of Dentistry
University of Toronto
Toronto, ON, Canada

Scott D. Ganz, DMD
Department Restorative Dentistry and Department of Diagnostic Imaging
Rutgers School of Dental Medicine
Newark, NJ, USA;
Private Practice
Maxillofacial Prosthodontics and Implant Dentistry
Fort Lee, NJ, USA

Andrew Horowitz, DMD, MD
Private Practice
New York Oral, Maxillofacial and Implant Surgery
Scarsdale, NY, USA;
Associate Attending
Division of Oral and Maxillofacial Surgery
White Plains Hospital
White Plains, NY, USA

Giles Horrocks, DDS, MS
Private Practice, Periodontics
Boulder, CO, USA

Ole T. Jensen, DDS, MS
Adjunct Professor
University of Utah, School of Dentistry
Salt Lake City, UT, USA

David M. Kim, DDS, DMSc
Assistant Professor
Division of Periodontology, Department of Oral Medicine, Infection and Immunity
Harvard School of Dental Medicine
Boston, MA, USA

Bach T. Le, DDS, MD, FICD, FACD
Clinical Associate Professor
Division of Oral & Maxillofacial Surgery
The Herman Ostrow School of Dentistry of USC
Los Angeles County/USC Medical Center
Los Angeles, CA, USA

Aldo Leopardi, BDS, DDS, MS
Private Practice, Prosthodontist
Greenwood Village, CO, USA

Craig M. Misch, DDS, MSD
Oral & Maxillofacial Surgery and Prosthodontics
Sarasota, FL, USA;
Clinical Associate Professor
Department of Implant Dentistry
New York University
New York, NY, USA

Earl Ness, DDS, MSD
Private Practice Prosthodontics
Spokane, WA, USA

Joerg Neugebauer, DDS, PhD
Department for Oral Surgery and Implantology
University of Cologne
Cologne, Germany;
Private office for dentistry, Landsberg am Lech, Germany

Marc L. Nevins, DDS, MMSc
Boston Periodontics & Dental Implants
Boston, MA, USA

Myron Nevins, DDS
Associate Clinical Professor
Division of Periodontology, Department of Oral Medicine, Infection and Immunity
Harvard School of Dental Medicine
Boston, MA, USA

Gary Orentlicher, DMD
Private Practice
New York Oral, Maxillofacial and Implant Surgery
Scarsdale, NY, USA;
Chief, Division of Oral and Maxillofacial Surgery
White Plains Hospital
White Plains, NY, USA

Howard Park, DMD, MD
Guest Lecturer
UCLA Department of OMS
Los Angeles, CA, USA

Cary A. Shapoff, DDS
Private Practice
Fairfield, CT, USA

Claudio Stacchi, DDS, MSc
Department of Medical, Surgical and Health Sciences
University of Trieste
Trieste, Italy

Tomaso Vercellotti, MD, DDS
Private Practice
Genoa, Italy;
Honorary Professor of University College of London
Eastman Dental Institute
London, UK

David Dara Yarmand, DDS, MD
Private Practice, OMS
Toronto, ON, Canada
Memorial to Jean-Francois Bedard

Remembering a great son, husband, father, and friend … To Deanna and all the family, words cannot describe your loss and sorrow. Any time spent with this special man was both a joy and privilege. Jean was and will always be the unique fun-loving soul that we all loved to be with. His love for you and the kids was both obvious and spoken. He treasured you greatly in his heart, and when he was away you were always on his mind. We shared with Jean many outstanding moments on the mountain, at meetings, at great restaurants, even in the Starbucks’ line … that will not be forgotten. Jean was kind hearted, passionate, exacting, and highly skilled. He truly enjoyed life to the fullest! Please accept our deepest sympathies, you will remain in our thoughts and prayers as you move forward through this tragedy.

Dan and Spring Cullum
Foreword

It has been a joy and privilege to be asked to write a Foreword for this beautiful book *Minimally Invasive Dental Implant Surgery*, edited by two eminent, world-renowned colleagues, Drs. Cullum and Deporter.

In the past years there has been an exponential increase in scientific information in implant dentistry, and it is really important that what is learned from basic and clinical research should flow in a clear and direct way to the practicing professional. In the field of biomedicine there is an ever increasing demand for minimally invasive procedures (e.g. robotic surgery) in order to decrease the biological costs for patients. Professional communities must be kept up to date on the most current findings and developments in diverse scientific areas.

Drs. Cullum and Deporter together with many outstanding contributors have provided, in this first-rate book, a comprehensive update of knowledge on many different facets of implant dentistry. This book is sorely needed, and provides an important resource to implant dentistry which covers the field thoroughly focusing on specific issues that confront the dental implant professional every day. All the most relevant aspects of today's implant dentistry have been covered in this book, and all the material is presented with a rigorous scientific approach. The information, such as the basic principles, the most recent advances, and practical applications, are presented in a well-integrated way. Beautiful illustrated case reports complete the book.

This book is a milestone contribution in implant dentistry, and will set a new standard for many years to come.

Prof. Adriano Piattelli, MD DDS
Professor of Oral Pathology and Medicine
Department of Medical, Oral and Biotechnological Sciences
School of Dentistry
University "Gabriele D'Annunzio", Chieti-Pescara, Chieti, Italy
Preface

Developing a minimally invasive mindset . . .

A new paradigm in dentistry began with the introduction of osseointegration and the predictable replacement of teeth with dental implants. Innovation and research have helped to refine the associated techniques such that today with careful planning and execution we are able to provide predictable and pleasing esthetic and functional implant treatments for our patients. Minimally invasive surgery is the next step . . . using the “least invasive” procedure, with the fewest number of steps and smallest cost. Surgery . . . simple, fast, and clean . . . when less is more.

Advances in technology now allow unprecedented diagnostic and planning capability. Following evidence-based protocols allows ideal implant placement even, where appropriate, with immediate implantation and immediate function. Choosing to utilize site preservation grafting at the time of tooth extraction lessens the later need for dedicated ridge augmentation grafting with its associated trauma and protracted treatment times. Combining or “stacking” multiple bone manipulation and soft tissue grafting procedures permits shorter treatment times, and using truly short implants helps to avoid complications in posterior jaw sites.

With surgery there is always risk. Flapless surgery can minimize surgical trauma, but comes with limited visibility and the potential for complications and unfavorable outcomes without adequate training and experience. Using computer-guided surgery also comes with risks and requires considerable time and investment to achieve competence. Technology is not a substitute for surgical training, experience or judgment, and significant perils often await its misapplication . . . when more is less.

The focus of this book is to provide a reference for predictable and minimally invasive surgical techniques that can be progressively applied within a construct of advancing skills. The contributors were carefully chosen with the purpose of exploring the field from different perspectives but with a common philosophy. As in other surgical disciplines, developing a minimally invasive mindset in implant dentistry requires a clear understanding of bone and soft tissue biology, wound healing, dental implant design, and the required surgical and/or prosthodontic skills to achieve predictable and optimal treatment outcomes. It is our hope that this book helps the practicing clinician to achieve these lofty goals.

Thank you to the team at Wiley Blackwell for their efforts and assistance.

Daniel R. Cullum DDS
Undertaking a comprehensive textbook is an ominous project. The time demand is more than one could ever have imagined. To that end I wish to thank my family and friends for the time we missed together: my wife Spring in particular has been outstanding in her support and love, my parents for teaching me to work, my dad for instilling a love for dentistry, my office staff and manager Lincoln, for the extra demands of business and busyness. A special thank you to Doug for his contribution and interaction, and to all of the contributors for their efforts and expertise. I want to also thank the many teachers and mentors who have influenced my career and praise God for gifting me with the strength, energy and skill to complete this project! Minimally invasive surgery is more demanding in time, skill and judgment, however, it has changed the way I practice and we want to share the many benefits for our patients.

Dan Cullum

I would like to thank Dan for giving me the opportunity to participate in this project. For over 25 years, I have striven to deliver minimally invasive dental implant treatment using short implants and the OSFE and BAOSFE approaches to sinus floor elevation. This book has been a challenging project. In the end I enjoyed the work and interacting with Dan, contributed a bit myself, and learned a lot from the contributors. Producing a comprehensive book like this one is a group effort. I would like to express my appreciation to all who contributed and wish them continued success and good health in future.

Douglas Deporter
Copyright note

The following contributors retain the copyright of the images listed below from their relevant chapters:

**Aldo Leopardi:**
Figures 4.1a,b, 4.4a–c, 4.5a–o, 4.6a–j, 4.7a–l, 4.8a–l, 4.9a–i,k–n, 4.10a–w

**Daniel R. Cullum:**
Figures 1.19a–c, 1.20a,b, 1.21a–f, 3.3a–c, 3.4, 3.7a–c, 3.12a–f, 5.3a–h, 5.4a–l, 8.5, 8.6, 8.8, 8.9, 8.18, 8.19, 11.5a–k, 12.5a–c, 12.7a–e, 12.10a–c, 12.11a–c, 15.1a,b, 15.2a–d, 15.4a–h, 15.8a,b, 15.10a–f, 15.11a,b, 15.12a–d, 15.3a–k, 15.14a–k, 15.15a–n, 15.17a–h, 15.18a–f, 15.19a–k, 15.20, 15.21 16.1a–c, 16.2b, 16.4a–e, 16.5b–f, 16.6, 16.7a,b, 16.8c,d, 16.9a–i, 16.10b–g,j, 16.11a–d, 16.12a–h, 16.13a–j, 16.14b–g, 16.15d,i,l, 16.17a–f, 17.1a–d, 17.2a, 17.3a–f, 17.4c,d, 17.5a–o, 17.6a, 17.7, 17.8b, 17.9a–e, 17.10a–o, 17.11a–v, 17.12d,e,j–n, 18.1a–c, 18.2a–c, 18.3a–g, 18.4a–f, 18.5a–j, 18.10a–o, 18.11a–c, 18.12a–i, 18.13a–t, 18.14a–i, 18.15a–j, 19.1c, 19.3d, 19.5a–c, 19.8a–k, 19.9a–e, 20.1a–d, 20.15a,b, 20.18a, 20.19c, 20.21a–f, 20.22a,b, 20.23a,b, 20.24h, 20.26a–c, 20.27a, 20.30c,e,g, 21.1a–w, 21.2c–f,h–r, 21.3a–x, 21.4a–h, 21.5a–x, 21.6a–w, 21.7e–q, 21.8a–h,k–n,p–t

**Bach T. Le:**
Figures 14.1, 14.2a,b, 14.3a–g, 14.4, 14.5a,b, 14.6a–l, 14.8a,b

**Earl Ness:**
Figures 21.2a–b,g,s–v, 21.2t–v, 21.7a–c, 21.8i,j,o
Technology, Diagnosis, and Treatment Planning
CHAPTER 1

Diagnosis and Treatment Planning for Minimally Invasive Dental Implant Treatment

Jean-Francois Bedard1 & Daniel R. Cullum2

1Private Practice, Prosthodontics, Denver, CO, USA
2Private Practice, Coeur d’Alene, ID; Loma Linda University Department of OMS, Loma Linda, CA; UCLA Department of OMS, Los Angeles, CA, USA

Introduction

While the recent trend in dental implantology has been toward less invasive surgical procedures, an argument can be made that the prosthetic phase has become more complex. Our desire to provide patients with minimally invasive treatment options requires that the diagnostic aspects be completed comprehensively. There is no “minimally invasive” diagnosis. Treatment options may be more or less invasive, but the diagnosis needs to be thorough and complete. Despite significant advances in dental implant technology, implants remain endosseous anchorage devices intended for prosthetic reconstruction of missing teeth.1

Many diagnostic tools, including cone beam computed tomography (CBCT) imaging and dental implant planning software (see also Chapters 2 and 9), have been developed to provide clinicians with user-friendly and precise methodology to examine and virtually plan possible therapeutic interventions.2 These technologies greatly facilitate communication with the patient and treatment team members.3 Clinicians should, however, use caution when applying these technologies and develop an understanding of their advantages and limitations. Restorative management of dental implants requires a clear understanding of the final restoration design, planning for the phases of treatment and anticipating contingency plans.4

In addition, it is important to realize that minimally invasive surgery does not imply less complexity or that less skill and judgment are necessary. On the contrary, often more skill and judgment are required with minimally invasive approaches, and clinicians should be trained and competent in both minimally invasive and traditional approaches. Clinicians providing surgical care also should be competent in anticipating, preventing, and managing potential surgical and prosthetic complications. Thus, the skills and judgments of the treatment team remain paramount.

For successful implant treatment outcomes, there must be sufficient quality and quantity of supporting hard and soft tissues, the implants must be in the proper number, location, and orientation, and the prosthesis must be fabricated with detailed attention to esthetics, phonetics, occlusal function, and access for oral hygiene.5 This chapter will address principles for the diagnosis and treatment planning for prosthetic reconstruction of commonly encountered clinical situations in the context of employing minimally invasive procedures.

The diagnostic process

Developing an accurate diagnosis is best achieved using a systematic process. Initial patient evaluation should begin with a subjective assessment, including chief complaint, history of the present illness or problem, and past dental and medical histories. A full discussion of the patient’s immediate concern (chief complaint), expectations, goals, and desires (immediate, short and long term) regarding treatment can prevent misunderstandings and help to avoid disappointments. While it is important to pay attention to the chief complaint, it is equally important not to let the chief complaint prevent a comprehensive approach in the clinical decision-making process. For example, patients presenting for single tooth replacement may not appreciate the need for a full diagnostic work-up and any additional treatment that might be required to achieve an optimal result. Consultation or referral to a more experienced clinician or implant team may be indicated if there is any discrepancy between the alignment of treatment goals and expectations and the clinical reality.

Following a thorough subjective assessment, the collection of objective diagnostic data begins. A focused head and neck examination and dental/oral examination are completed, with special attention given to teeth opposing and adjacent to potential implant sites. A complete periodontal examination, including probing, should be a part of the diagnostic record. The periodontal evaluation also should include an esthetic evaluation of the gingiva, including gingival display, symmetry, and biotype. An occlusal evaluation is necessary, with special attention afforded to vertical space relationships, interdental spaces, attrition, deep bite, cross-bite, and any other issues that might potentially impact the prosthetic outcome.

Radiographic evaluation may include any or all of periapical radiography, panoramic radiography, and CBCT 3-D imaging of the affected jaw(s) and proposed implant site(s).2 Following the initial diagnostic examination, more sophisticated planning may be required with the use of surgical guides or templates fabricated from diagnostic wax-ups and/or tooth set-ups and 3-D planning.6 A record of the bite relationship should be taken in wax or a suitable elastomeric material, and diagnostic casts prepared. Mounting of these casts with a facebow transfer is ideal, especially if a diagnostic wax-up is being done.

Digital photographs are an important aspect in diagnosis to help communicate clinical and technical information to patients, dental
colleagues, and laboratory technicians. Referring to a digital photograph will help to answer questions that can arise in the treatment after teeth have been removed or otherwise altered. Extraoral photographs should be taken from both lateral and frontal views with the lips in repose as well as during a full smile. Intraoral photographs should include an occlusal view of each arch, a frontal view with the teeth in full contact, and right and left lateral views. The camera system need not be elaborate or complex; however, a modern digital single-lens reflex camera with macro lens and a dedicated macro flash system will give the best results. In addition, it is suggested that a high-quality set of intraoral mirrors and lip retractors be available, and that both the dentist and clinical staff be trained in their proper use.

Following a thorough review of the findings and, if need be, consultation with specialists, a set of treatment options is developed. The clinician is required to put all the findings together and come up with possible solutions. As a part of the diagnosis, a risk assessment is completed, including the demands of the case and whether or not a minimally invasive treatment approach is appropriate and/or involvement of other experienced colleagues is indicated.

This process must be purposeful and lead to a plan with the patient’s full understanding and support. A plan is rarely a single option, but rather a discussion encompassing multiple possibilities even though some options may be eliminated quickly based on a patient’s desires (for example, a reluctance to accept a removable prosthesis). Some treatment options may require additions to the basic plan (for example, a patient requiring multiple implants to be placed in order to secure a prosthesis may require bone augmentation or reduction procedures prior to implant placement). The final plan should include an indication of advantages and disadvantages, expected prognosis, costs, and possible complications in order to adequately inform the patient prior to their consent.

**Informed consent**

Informed consent involves more than simply presenting a few treatment alternatives. The patient should fully understand the associated risks, benefits, and limitations, including possible complications and alternatives for any treatment proposal. The first treatment option should always be “no treatment,” and the implications of that decision should be considered and discussed. Many patients will be concerned regarding the anticipated esthetic outcome, and this should be discussed and documented fully in advance. There is no substitute for a set of mounted models with a diagnostic wax-up to directly visualize the proposed treatment. Digital photographs, 3-D imaging and planning, and a wax try-in or mock-up of the proposed treatment are important aspects of planning and informed consent. Patients should have an opportunity to have all of their questions answered, preferably with a friend or loved one in attendance, and this will often require more than one interaction. Diligence at this phase of treatment is critical to developing trust and rapport with the patient for those inevitable challenges that can occur.

**Comprehensive evaluation and risk assessment**

Comprehensive examination begins before the patient is seated in the dental operatory. Evaluation of the patient begins with interactions while standing and sitting upright during normal conversation. This is best facilitated in a consultation room with a home living room environment. Most patients begin adaptive responses and compensations when placed in the dental operatory and in a reclined position. The patient and clinician will benefit from a systematic approach and review of the findings.

**Facial analysis**

Evaluation of facial dimension includes inspection of facial symmetry from the frontal (Figure 1.1a), lateral, and three-quarter views. This inspection will allow confirmation that the facial thirds are harmonious (Figure 1.1b) and determination of the skeletal classification (Class I, II, or III). Diagnosis of the facial type (brachiocephalic versus dolicocephalic) can have significant implications with the amount of bite force generated on posterior teeth and the importance of anterior guidance (deep bite versus open bite). Further examination and palpation of the head and neck include the muscles of mastication to evaluate for hyperactivity or myosperm, temporomandibular joint disorders affecting mandibular range of motion or discomfort, and to rule out the presence of any masses, suspicious lymphadenopathies, or sinus issues.

![Figure 1.1](image)

(a) Facial perspectives and proportions. (b) Facial perspectives and proportions projected over face.
Dento-facial analysis

Evaluation of the esthetic zone – incisal plane, plane of occlusion, incisal edge position, dental/facial midlines, lip support, and gingival display – is included in the dento-facial analysis\(^8\) (Figure 1.2a). Digital photography is indispensable for this pretreatment evaluation. Careful and systematic investigation of these features may change what appears initially to be a simple, single-tooth case into a complex interdisciplinary restorative challenge with increased treatment risk. On frontal evaluation, the anterior incisal plane should be parallel to the interpupillary plane and curve upwards in the canine region to follow the contours of the lower lip and the Frankfort horizontal plane\(^9\) (Figure 1.2b). The plane of occlusion should follow the interpalpebral line, the curve of Spee, the curve of Wilson, and the curve of Monson\(^10\) (Figure 1.3).

Incisal edge position and tooth display at rest are patient-specific. Consideration of empirically determined norms can be helpful as the amount of display is age and gender dependent, excluding other variables such as lip length and lip movement on animation.\(^11\) Accepted guidelines for the position of the maxillary central incisal edge at rest is 3.4 mm in females and 1.9 mm in males "below the lip". If the patient has a "short" upper lip, then exposure can be as much as 3.65 mm; with a "long" upper lip exposure can be as little as 0.59 mm.\(^12\) With aging, tooth exposure generally decreases due to lip laxity and decreased animation, and can be further reduced with incisal edge wear (see "Dento-gingival analysis" section). The accepted guidelines range from 3.37 mm of exposure for patients younger than 29 years of age to as little as 1.26 mm for those up to 50 years of age.

Assessment of the facial and dento-facial midlines for alignment will reveal any significant horizontal or vertical asymmetry, and any orthodontic, orthognathic, and/or facial plastic surgical treatment that may be indicated\(^12\) (see Chapter 20). If significant dental asymmetry is found, orthodontic treatment (see Chapter 20) and/or prosthetic restoration of adjacent or opposing teeth may be required (Figure 1.4).

A key determinant of esthetic risk in implant therapy is the amount of gingival display exhibited during a full smile.\(^7\) If there is no exposure of the dento-gingival margin, the primary esthetic considerations are limited to tooth shade, tooth width, and incisal edge anatomy.\(^13\) Conversely, if there is full exposure of the gingival margin, then the entire dento-gingival complex must be considered, and the esthetic demands of the case will increase exponentially. If it is
Technology, Diagnosis, and Treatment Planning

17

1.4

right canines and lateral incisors became the focus of the treatment plan because of disharmony. (Figure 1.6a and d). The treatment plan in this case consisted of gingivoplasty to increase the length of the right crowns relative to the contralateral teeth. Restorative treatment included narrowing the width of the right lateral incisor and increasing the width of the cuspids to achieve more pleasing proportions (Figure 1.6c). These changes were first evaluated by digital superimposition of a mirror image of the left cuspids and lateral incisors onto the right side. Thereafter, the teeth were prepared and restored with provisional restorations (Figure 1.6f).

Lip support
In addition to support from alveolar bone and soft tissue, the upper lip is mainly supported by the gingival two-thirds of the anterior maxillary teeth, not the incisal one-third. The shape and volume of the anterior maxillary alveolus (relative undercut and proclination) and the effects of aging with altered muscle tone also will effect labial position and mobility on animation.

Gingival biotype
Gingival biotype is another key determinant in esthetic risk. Patients exhibiting a thin, scalloped gingival biotype are more likely to have translucency of the underlying restorative material and/or buccal soft tissue recession over time and, as a result, may show exposed implant components. (See also Chapter 3. The possible need for modification of the gingival biotype (see also Chapter 8), either preoperatively or following completion of the treatment, is best discussed before treatment begins.

Interdental papilla
Normal interdental papilla reformation following implant restoration is one of the most challenging outcomes in implant dentistry. The height and symmetry of interdental papillae following implant restoration are determined by the height of the interproximal bone crest of the adjacent tooth or implant. A single tooth implant placed between two healthy natural teeth has the best prognosis for reforming esthetically pleasing papillae. In such situations, papillae with 4.0–4.5 mm of soft tissue height can be anticipated (see further discussion in “Planning for ideal implant position” section). Tooth shape is also an important factor in predicting the presence or absence of esthetically pleasing interdental papillae. Square crown forms typically have shorter, thicker papillae and interproximal contacts, which may extend into the middle third of the clinical crown. Conversely, teeth with long, tapered crown shapes have thinner and more delicate papillae, and the interproximal contact zone may be limited to the incisal third of the crown. In this latter situation, when an extraction is done even in a minimally traumatic fashion, recession of papillae and incomplete soft tissue fill between crowns is a common finding.

Maxillary central incisor position
This is the key to anterior esthetics, and is the foundation for the diagnostic and treatment processes. Concepts such as dominance (relative size/shade), symmetry, proportions, and incisal edge position must be understood and applied if esthetic success is to be achieved.

Tooth proportion
Tooth proportion may ultimately be influenced by factors beyond the control of the implant surgeon, such as orthodontic positioning and tooth migration. Guidelines for ideal proportions include a

determined that there is altered passive eruption, vertical maxillary excess, or excessive gingival display due to hypermobility of the lip, then periodontal crown lengthening, fixed prosthetic enhancement, surgical, or orthodontic treatment options are best addressed preoperatively along with anticipated limitations in treatment outcome.

Dento-gingival analysis

Gingival plane
Generally, a patient’s maxillary anterior teeth display similar gingival length and proportions. The maxillary canines and central incisors may have slightly longer gingival contours than the lateral incisors with relatively more tooth exposure. (Figure 1.5a–c) The maxillary anterior teeth are progressively inclined to the distal, placing the gingival zeniths slightly distal to the midpoint of the tooth width. Tooth shape, tooth positions, and loss of bone or soft tissue support will cause discrepancies in gingival and/or papilla height. Generally, the closer to the midline these discrepancies occur, the more significant their impact will be. Facial angulation or positioning moves the gingival margin apically. Schematics representing tissue defects and gingival levels can aid diagnosis and risk assessment in treatment planning (Figure 1.5b–g) Options to manage gingival height discrepancy include orthodontic treatment, prosthetic soft tissue manipulation with long-term provisional restorations, and/or gingival surgery.

Modification of the gingival levels is often desirable and should be considered during the treatment planning process. Figure 1.6a and b shows a young female patient who presented with a significant asymmetry in the esthetic zone. On dento-facial and dento-gingival evaluation of her smile, the proportions of the maxillary right canines and lateral incisors became the focus of the treatment objectives. Because the left canine and lateral incisor presented with pleasing proportions, a reasonable approach was to reproduce them to the degree possible on the right side (Figure 1.6c and d). The treatment plan in this case consisted of gingivoplasty to increase the length of the right crowns relative to the contralateral teeth. Restorative treatment included narrowing the width of the right lateral incisor and increasing the width of the cuspids to achieve more pleasing proportions (Figure 1.6c). These changes were first evaluated by digital superimposition of a mirror image of the left cuspids and lateral incisors teeth onto the right side. Thereafter, the teeth were prepared and restored with provisional restorations (Figure 1.6f).

Figure 1.4 (a) Anterior smile view of preoperative disharmony. (b) Anterior smile view after camouflage of disharmony harmony.

(a)

(b)
Figure 1.5 (a) Esthetic dento-gingival presentation demonstrating the free gingival margin of maxillary anterior dentition. (b) Same as (a) with teeth outlines drawn. Imaginary lines joining gingival margins of canines to centrals; laterals should ideally be shorter or even with this line. Note that the planes slope downward towards the midline. (c) Diagrammatic representation of (b). (d) Variation #1 (of gingival levels): the right canine is longer gingivally, but perspective is maintained. (e) Variation #2: the right canine and central incisor are longer gingivally, but the gingival plane remains in relative harmony as it slants downward. (f) Dysharmony #1: the right central incisor is significantly longer than in (c), creating a more significant unilateral asymmetry because of the upward plane toward midline. (g) Dysharmony #2: right central incisor is very long gingivally creating visual tension away from ideal plane.
Axial inclination of the maxillary anterior teeth tends to be progressively distal, and this fact will influence the contours of the gingival soft tissue, with the gingival zeniths of the anterior maxillary teeth slightly distal to the mid-tooth width (as discussed previously). This outcome may be difficult to achieve with a dental implant due to size, shape, and proximity limitations. Soft tissue manipulation with long-term provisional restorations (see also Chapter 4), and/or gingival surgery (see also Chapter 8), may be helpful in this regard and should be considered in the initial restorative treatment plan.

Incisal embrasure anatomy
Incisal embrasure anatomy also can influence tooth proportion and shape. The relative angles and depth of a youthful adult incisal embrasure anatomy are shown in Figure 1.8a. With aging and incisal wear, the incisal embrasure depth becomes reduced, and it may even disappear with extreme wear (Figure 1.8b). If lengthening the tooth

\[ W : L \approx 75\% \text{ to } 80\% \] (Figure 1.7a). For diagnostic purposes, a \( W : L \) ratio greater than 85% is indicative of a “short, square” tooth form, while a \( W : L \) ratio less than 75% is indicative of a “long, narrow” tooth form (Figure 1.7b and c).

Tooth shape
Tooth shape includes considerable variations in form: round/ovoid, square, or tapered. The shape influences the position of the contact point with the adjacent teeth and embrasure depth. Restoration with a square-shaped crown form fills the embrasure space with restorative material and moves the interproximal contact point apically. As noted previously, tooth shape plays a role in the dimensions of interdental papillae.\(^1\) Patients with a square tooth form typically have a “high crest” bone anatomy, whereas triangular-shaped or ovoid crown forms are more likely to have a “low crest” bone anatomy with a longer zone of soft tissue attachment, and are at higher risk of unfavorable papilla reformation and recession.\(^1\)

**Figure 1.6** (a) Anterior smile view demonstrating significant white and pink disproportions of the right lateral incisor. (b) Right lateral smile view. (c) Esthetic analysis on laboratory study cast. (d) Esthetic superimposition of the left canine and lateral incisor mirror images over the right canine and lateral incisor sites. (e) Same as (d) but with preoperative right canine and lateral incisor teeth eliminated. (f) Anterior retracted dentition of provisional crowns immediately post-insertion; note slight tissue recontouring with diamond gingivoplasty at the right lateral incisor.
Diagnosis and Treatment Planning

Figure 1.7 (a) Ideal width-to-length ratio of maxillary central incisors (75–80%). (b) Short tooth width-to-length ratio (larger than 75–80%). (c) Long tooth width-to-length ratio (smaller than 75–80%).

Figure 1.8 (a) A youthful incisal embrasure anatomy. (b) Variation in incisal embrasure anatomy and depth of incisal planes; the flatter the embrasures (top of figure), the more worn/aged teeth will look. The deeper the embrasures (bottom of figure), the younger the dentition will appear.

Figure 1.9 (a) Mesio-distal contours: given a particular width for a tooth to occupy a desired space, moving the facial height of contours inward will "round" a tooth, making it look "narrower" (and vice versa). (b) Gingivo-incisal contours: given a particular length for a tooth to occupy a desired space, accentuating the labial planes will also "round" a tooth, making it look "shorter" (and vice versa).

is not an option, a simple and effective way to provide a more youthful appearance is to deepen the existing incisal embrasures interproximally. For a more natural appearance, the incisal embrasure of the maxillary lateral incisor should be more pronounced.

Prosthetic modifications of contour and illusion can be used to improve harmony and solve width and/or height imbalances at single or adjacent tooth/implant sites. Moving the facial height of contours inward will "round" a tooth, making it look "narrower"; accentuating the labial planes will also "round" a tooth, making it look "shorter" (Figure 1.9). While these techniques often can help rescue a challenging treatment scenario, the patient should be advised in advance as to the possible limitations of therapy.
The patient in Figure 1.10 presented for implant consultation to replace a hopeless maxillary left central incisor. The right central incisor had a favorable prognosis. The primary esthetic challenge was a large midline diastema developed following buccal migration of the left incisor secondary to advanced periodontal disease (Figure 1.10a). Prior to treatment, a digital plan was presented to the patient for approval, and to determine if additional treatment of the adjacent teeth would be required to achieve ideal proportions and symmetry (Figure 1.10b and c). The patient accepted slightly larger than ideal central incisor restorations in order to avoid having to restore the lateral incisors (Figure 1.10d).

In cases having a long tapered crown shape and significant interproximal bone and papilla loss, restoration of the teeth adjacent to the implant with veneers or full-coverage restorations may be required in order to move the interproximal contact point apically. This change can achieve a more overall esthetic result, but can result in less than ideal tooth esthetics and squarer proportions. If complex restorative treatments are required to achieve ideal esthetics, it is preferable to advise the patient of this possibility during the treatment planning stage, and have all members of the implant team involved in the decision-making process.

Figure 1.11a–c presents a patient with significant occlusal and esthetic compromise resulting from years of parafunctional occlusal habits combined with chemical erosion and periodontal attachment loss. Performing preoperative direct restorative mock-up procedures can allow these patients to be presented with potential treatment options. In this instance, composite resin was layered and cured onto the incisal aspects without the use of etching or adhesive (Figure 1.11d). Orthodontic wax was used to fill in the open interproximal spaces or “black triangles,” creating the illusion that those spaces had been closed (Figure 1.11e and f). This intraoral mock-up was evaluated by the patient, documented with photographs, and duplicated with an alginate impression for the creation of a mock-up cast. The desired final contours were completed with a diagnostic wax-up, allowing predictable replication of contours by the laboratory technician. The definitive porcelain restorations with modified shape and proportions are shown in Figure 1.11g and h.

**Inter-arch and vertical space**

Inter-arch and vertical space requirements can be one of the most confounding aspects of implant restorative treatment planning, making it imperative to complete a thorough analysis of the inter-arch space in all excursions of the mandible. For single restorations, adequate occlusal thickness for the restorative
Figure 1.11 (a) Anterior smile view presents a patient with significant occlusal and esthetic compromise resulting from parafunctional occlusal habits combined with chemical erosion and periodontal recession. (b) Right lateral smile view. (c) Retracted view of the maxillary teeth. (d) Retracted maxillary anterior “mock-up” with rapid freehand addition of composite resin (without bonding agent). (e) Retracted maxillary anterior “mock-up” with white orthodontic wax pressed into gingival embrasures. (f) Anterior smile view of completed rapid “mock-up.” (g) Anterior retracted view of completed definitive restorations with modified shape and proportions. (h) Right lateral smile view of completed definitive restorations.
material is mandatory. For zirconium or metal, a minimum of 1.0 mm is required. For lithium disilicate and porcelain-fused-to-metal (PFM) restorations, a minimum of 1.5 mm thickness is required. The cross-sectional areas required for connector zones for splinted multiple unit restorations are 12 mm² for short-span zirconia/PFM and 20 mm² for longer span zirconia bridges and PFM restorations. Modification of inadequate inter-arch dimension and an abnormal occlusal plane due to extruded opposing teeth can be completed with restorative and/or orthodontic procedures, although the vertical depth of implant placement also must be considered for single restorations. Vertical surgical bone reduction may be needed to achieve adequate prosthetic space for full-arch implant rehabilitations.

Occlusal stability
Occlusal stability can be improved by idealizing the maxillary anterior cingulum region to provide a stable platform for light centric contacts of implant crowns with the incisal edges of the mandibular anterior teeth. Similarly, recreating simple cusp-to-fossa occlusal contacts in posterior implant restorations should be the goal.

Anterior guidance
Anterior guidance describes the role of the anterior teeth to provide discusion of the posterior teeth during mandibular movements. The angle of this guidance should be steep enough to achieve posterior discusion as well as adequate vertical space between the posterior teeth during discusion. To minimize the effects of potentially damaging forces, the angle of the anterior guidance should be kept to a minimum to reduce lateral and protrusive forces exerted on the anterior teeth. The use of facebow-mounted casts will aid diagnosis, restoration development with the aid of provisionals, and preservation of this critical relationship for use by the laboratory technician.

Phonetics
Natural tooth position and the contours of a fixed or removable prosthesis will influence the quality of speech. Poor tissue profile design with fixed bridges also can lead to difficulty in home-care access and professional maintenance. Poor planning can lead to exaggerated thickness of a removable overdenture or fixed bridge, making it difficult for patients to tolerate the contours and adapt functionally. Improperly designed air space (inadequate pontic design) under a fixed prosthesis (particularly in maxillary arch) can lead to air escape at the tissue level, causing difficulty with pronunciation of sibilants. Evaluation of esthetics and phonetics is dynamic, and requires the patient to pronounce “E,” “M,” “S,” “F,” and “V” sounds. Having the patient pronounce “E” will exaggerate lip movements and permit easier visualization of the full extent of the esthetic zone. “M” sounds are used to determine the relaxed rest position (vertical dimension of occlusion at rest), as well as the amount of tooth display at rest. In order for “S” sounds (i.e. closest speaking space or vertical speech dimension) to be clear and not “SH-like,” the edges of the mandibular anterior incisors should come in “near” contact (“almost” touching) with the lingual of the maxillary incisal edges. Variations can be addressed and corrected as necessary. Finally, for correct pronunciation of “F” and “V” sounds, the incisal edges of the maxillary central incisors ideally need to make contact with the dry–wet line of the lower lip.

Dynamic evaluation of these sounds helps the clinician determine the angulation of the incisal third of the maxillary teeth/implant crowns. The use of provisional restorations can be helpful in facilitating prosthesis design, allowing minor adjustments and a trial period prior to the definitive restoration. Variations expected with each patient can be addressed and corrected. Esthetic zone analysis and the balance of dento-gingival esthetics also require this functional phonic assessment.

The esthetic zone: pink and white esthetic concepts
The esthetic zone is on display during normal speech or animation. Included in the esthetic zone are the “white” esthetics (teeth – presence or absence, symmetry, proportions, etc.) and “pink” esthetics (gingiva – presence or absence, symmetry, color, texture, etc.). White and pink esthetic scores can be helpful for

Figure 1.12 (a, b) Inter-arch and vertical space requirements for prosthesis design need to account for the vertical height of the abutment, major connector, and restorative materials. Source: Nobel Biocare. Reproduced with permission of Nobel Biocare, Yorba Linda, CA.
objective assessment as well as in clinical research. However, the overall esthetic outcome is multifactorial and depends on patient expectations and the levels of gingival display. A fundamental challenge in contemporary esthetic implant dentistry is providing a restoration with the proper balance of soft and hard tissue esthetics. Soft tissue contours are critical in high demand cases, and are only predictable with adequate underlying bone support. Bone augmentation, soft tissue augmentation, or a combination are often required in order to provide the foundation for the restoration of esthetic balance (see also Chapters 5, 7, and 8). These augmentation procedures are time-consuming, involve significant financial commitment, and often require the involvement of multiple specialists.

At times, minimally invasive treatment philosophy may dictate a different approach from traditional implant reconstructions. A patient requiring extensive bone augmentation and soft tissue procedures to reconstruct a large alveolar defect may benefit from a less invasive treatment with short, narrow, or angled implant placement (see Chapters 10–12). These techniques can be used with a prosthesis designed with pink porcelain or pink acrylic for replication of the gingival contours. Similarly, a patient with severe periodontal bone loss desiring a full-arch reconstruction may benefit from a less invasive treatment such as a full-arch, screw-retained prosthesis supported by four implants compared with a traditional fixed prosthetic approach involving bilateral bone augmentation and eight or more implants (see “The falling dentition/completely edentulous patient” section and Chapter 12).

A patient who was treated with a minimally invasive approach is demonstrated in Figure 1.13. The patient suffered a traumatic injury to the anterior maxilla. Clinical and periapical radiographic images showed a significant bone and soft tissue defect after loss of the right lateral incisor, canine, and first premolar teeth (Figure 1.13a and b). It was possible to reconstruct this large defect with an implant-supported restoration including a pink esthetic fixed prosthetic with excellent white and pink balance and shade match (Figure 1.13c). The use of a screw-retained prosthesis allowed for periodic removal as needed for prosthesis maintenance and repair.

Placement of the transition line between the prosthetic teeth and soft tissue is an important consideration with the use of pink porcelain or acrylic for replacement of missing soft tissue. Often, the transition line can detract from an otherwise acceptable result. In patients with a low lip line, the vertical or horizontal placement of the transition line is usually not critical. However, all patients should be evaluated for possible maximum display of the prosthesis during an exaggerated smile (“E” sounds). If the transition line is in view, acceptability of the esthetics should be discussed and finalized with the patient. If a horizontal transition line is unacceptable, the implant position may need to be more apical or a labial flange can be used to modify the prosthesis to move the transition line apically with the use of a bar overdenture prosthesis design (see Figure 1.20 and discussion further on). This also requires adequate prosthetic space but allows for adequate hygiene maintenance. The addition of a flange to a fixed prosthesis will result in poor prosthesis contours and limit access for hygiene and professional maintenance, even with the use of a screw-retained prosthesis in these challenging scenarios. Planning and appropriate implant positioning must be determined by the prosthetic plan.

Figure 1.13 (a) Clinical and (b) periapical radiographic images show a significant bone and soft tissue defect after traumatic injury with the loss of the right lateral incisor, canine, and first premolar teeth. (c) It was possible to reconstruct this large defect with an implant-supported restoration using a pink esthetic fixed prosthetic with excellent white and pink balance.
Planning for ideal implant position

The interproximal space between implants and/or teeth is an important consideration for bone and soft tissue stability. Dental implants have no periodontal attachment apparatus with the associated blood supply to help to maintain the interproximal height of bone that is critical for predictable soft tissue levels. Table 1.1 provides a summary of the key dimensions and a classification for tooth and implant spacing and interproximal vertical soft tissue height.

These tissue levels are the result of the bucco-palatal bone width and the vertical and horizontal crestal bone remodeling secondary to the establishment of the biologic width around implants (see Chapter 8, Figure 8.3a and b). For an implant adjacent to a natural tooth, an interproximal distance of 1.0–1.5 mm is required to avoid interproximal bone loss. Between adjacent implants, an interproximal distance of 3.0–3.5 mm must be maintained to prevent or minimize interproximal bone loss.

If adjacent implants are placed too close, exaggerated vertical bone loss can result due to merging of the two zones of horizontal crestal remodeling between the implants. Platform-switching and implant design modifications also can help to minimize this remodeling when these crucial interproximal distances cannot be achieved (see further discussion in Chapters 3 and 4).

The ideal corono-apical position or depth of placement of the implant prosthetic platform should be 2.0–3.0 mm below the gingival zenith of the proposed implant restoration. The patient shown in Figure 1.14 presented with an esthetically displeasing conventional bonded bridge replacing the maxillary lateral incisors bilaterally. With careful planning for the final level of the free gingival margins of the right and left maxillary lateral incisors, appropriate implant placements were achieved. Figure 1.14b shows an anterior retracted clinical view with superimposed proposed implants in position, with the red lines representing the desired height of the free gingival zeniths. The dotted white lines represent the desired outlines of the new restorations. The provisional crowns are shown in Figure 1.14c after initial soft tissue maturation.

Bucco-lingual implant positioning also is important in maintaining esthetic and functional stability. In the esthetic zone, the buccal plate thickness of natural teeth measures between 0.5 and 2.5 mm at the crest. Preserving this buccal bone or augmentation with hard tissue grafting at implant placement should ensure that a thickness of 2.0 mm or greater is maintained to have predictable and stable hard and soft tissue contours over the facial aspect of the implant. Relationships of the osseous crest and correct bucco-lingual implant placement and trajectory are demonstrated in Figure 1.15. This male patient presented with a chief complaint of a non-restorable, endodontic-treated maxillary left central incisor.

<p>| Table 1.1 Salama et al. classification of predicted height of interdental papillae |
|---------------------------------|-----------------|-------------------|</p>
<table>
<thead>
<tr>
<th>Class</th>
<th>Restorative environment</th>
<th>Proximity limitations (mm)</th>
<th>Vertical soft tissue limitations (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tooth-tooth</td>
<td>1.0</td>
<td>≥0.0</td>
</tr>
<tr>
<td>2</td>
<td>Tooth-pontic</td>
<td>N/A</td>
<td>6.5</td>
</tr>
<tr>
<td>3</td>
<td>Pontic-pontic</td>
<td>N/A</td>
<td>6.0</td>
</tr>
<tr>
<td>4</td>
<td>Tooth-implant</td>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>5</td>
<td>Implant-pontic</td>
<td>N/A</td>
<td>5.5</td>
</tr>
<tr>
<td>6</td>
<td>Implant-implant</td>
<td>3.1</td>
<td>3.5</td>
</tr>
</tbody>
</table>


(Figure 1.15a) There was significant recurrent decay within the canal preparation (Figure 1.15b). The surrounding soft and hard tissues appeared adequate for a planned implant-supported restoration. The interproximal bony peaks were intact 4.5 mm apical from the desired interproximal contact zones on the mesial and distal (Figure 1.15c). The osseous crest was located 3.0 mm away from the buccal and lingual free gingival margins.

Digital treatment planning included superimposition of the left central incisor mirror image over the edentulous space (Figure 1.15d and e) to evaluate the mesio-distal space requirements.
Figure 1.15 (a) Retracted anterior preoperative view of failing maxillary right central incisor. (b) Occlusal view of root fragment after removal of the failing crown. (c) Preoperative periapical radiograph showing intact interproximal bone. (d) Anterior retracted view with superimposed mirror image tracing for tooth shape analysis. (e) Superimposed mirror image tracing for tooth shape analysis with proposed midline and the shaded outline of the proposed restoration. (f) Occlusal view of dangerous bucco-lingual positioning for implant placement in the esthetic zone (too facial). (g) Occlusal view of idealized bucco-lingual positioning for implant planning in the esthetic zone, maintaining at least 2 mm facial gap.

(Continued)
(h) Occlusal view of analysis of bucco-lingual angulation with the access hole location for planned restoration through the incisal edge of the future crown. (i) Occlusal view of analysis of bucco-lingual angulation with the access hole location for planned restoration through the cingulum of future crown. (j) Lateral view of the study cast with a sagittal view representation of (i) showing implant angulation relative to desired restored crown anatomy. The location of the access hole for screw retention is visualized through the cingulum. (k) Occlusal view of the implant and peri-implant soft tissues 4 months post-extraction with an immediate fixed provisional restoration. (l) Anterior retracted view of definitive implant crown at the central incisor. (m) Periapical radiograph of definitive implant restoration.