

Edited by

John Beumer III, DDS, MS

Robert F. Faulkner, DDS, MS

Kumar C. Shah, BDS, MS

Benjamin M. Wu, DDS, PhD

SECOND EDITION

Fundamentals of Implant Dentistry

VOLUME 1 *Prosthodontic Principles*

Fundamentals of Implant Dentistry
Volume 1: Prosthodontic Principles
Second Edition



One book, one tree: In support of reforestation worldwide and to address the climate crisis, for every book sold Quintessence Publishing will plant a tree (<https://onetreeplanted.org/>).

Library of Congress Cataloging-in-Publication Data

Names: Beumer, John, III, 1941- editor. | Faulkner, Robert F., editor. |

Shah, Kumar C., editor. | Wu, Benjamin M., 1962- editor.

Title: Fundamentals of implant dentistry / edited by John Beumer III,

Robert F. Faulkner, Kumar C. Shah, Benjamin M. Wu.

Description: Second edition. | Batavia, IL : Quintessence Publishing, Co, Inc, [2022]- | Includes bibliographical references and index. |

Contents: v. 1. Prosthodontic principles | Summary:

“Textbook covers restorative treatment options for edentulous and partially edentulous

situations, from relatively simple problems that can be handled by a solo practitioner to those with substantial prosthodontic complexities,

periodontal compromise of existing dentition, and significant bone and soft tissue defects”-- Provided by publisher.

Identifiers: LCCN 2021042809 (print) | LCCN 2021042810 (ebook) | ISBN 9780867159523 (v. 1 ; hardcover) | ISBN 9781647241155 (v. 1 ; ebook) Subjects: MESH: Dental Implants | Dental Implantation--methods | Tooth Diseases—surgery Classification: LCC RK667.I45 (print) | LCC RK667.I45 (ebook) | NLM WU 640 | DDC 617.6/93--dc23 LC record available at <https://lccn.loc.gov/2021042809> LC ebook record available at <https://lccn.loc.gov/2021042810>

A CIP record for this book is available from the British Library.

ISBN: 9780867159523



© 2022 Quintessence Publishing Co, Inc

Quintessence Publishing Co, Inc
411 N Raddant Road
Batavia, IL 60510
www.quintpub.com

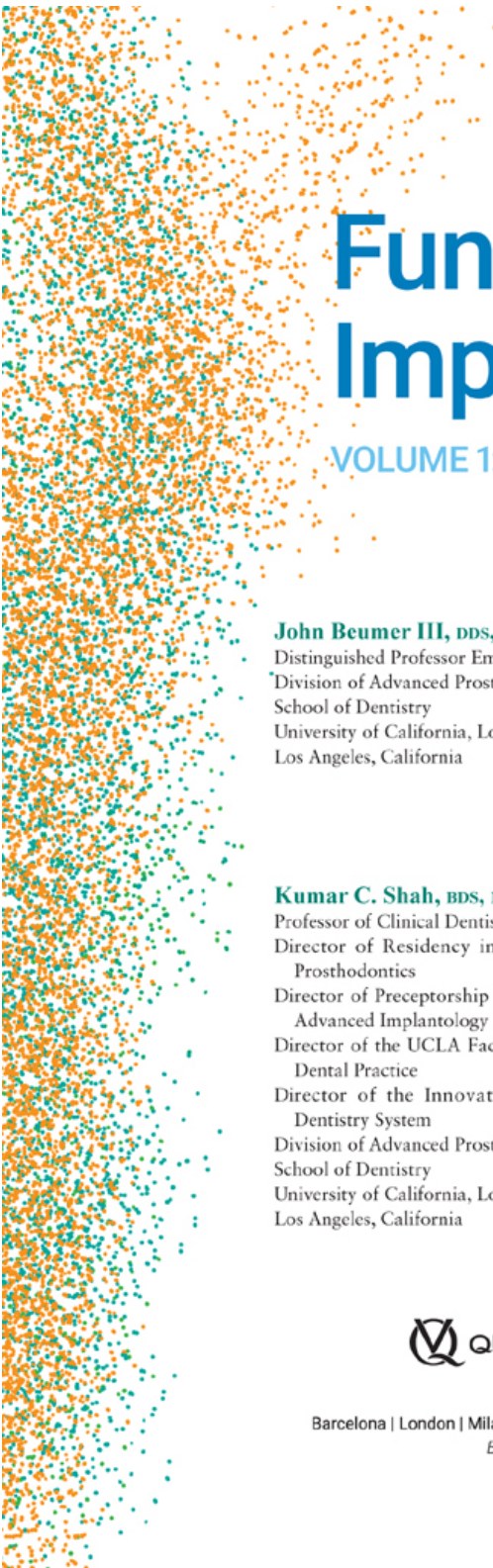
5 4 3 2 1

All rights reserved. This book or any part thereof may not be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, or otherwise, without prior written permission of the publisher.

Editors: Zachary Kocanda & Marieke Z. Swerski

Design: Sue Zubek

Production: Sarah Minor



Fundamentals of Implant Dentistry

VOLUME 1: *Prosthodontic Principles*

Edited by

John Beumer III, DDS, MS

Distinguished Professor Emeritus
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California

Robert F. Faulkner, DDS, MS

Lecturer
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California

Private Practice
Cincinnati, Ohio

Kumar C. Shah, BDS, MS

Professor of Clinical Dentistry
Director of Residency in Advanced
Prosthodontics
Director of Preceptorship Program in
Advanced Implantology
Director of the UCLA Faculty Group
Dental Practice
Director of the Innovative Digital
Dentistry System
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California

Benjamin M. Wu, DDS, PhD

Professor and Chair
Division of Advanced Prosthodontics
Director of the Weintraub Center for
Reconstructive Biotechnology
Executive Director of the Innovative Digital
Dentistry System
School of Dentistry

Professor
Departments of Bioengineering, and Mate-
rials Science and Engineering
School of Engineering
University of California, Los Angeles
Los Angeles, California

 **QUINTESSENCE PUBLISHING**

Berlin | Chicago | Tokyo
Barcelona | London | Milan | Mexico City | Moscow | Paris | Prague | Seoul | Warsaw
Beijing | Istanbul | Sao Paulo | Zagreb

CONTENTS

Dedication

Preface

Contributors

Section I: Foundational Principles

- 1** History and Biologic Foundations
- 2** Osseointegration, Its Maintenance, and Recent Advances in Implant Surface Bioreactivity
- 3** Implant Biomechanics, Screw Mechanics, and Occlusal Concepts for Implant Patients
- 4** Contemporary Implant Materials
- 5** Digital Technologies and Implant Dentistry

Section II: Restoration of Edentulous Patients

- 6** Edentulous Patients: Patterns of Bone Resorption and Clinical Outcomes with Implants
- 7** Restoration of Edentulous Mandibles with Overdentures
- 8** Restoration of Edentulous Mandibles with Fixed Protheses
- 9** Restoration of Edentulous Maxillae with Implant-Retained Overdentures
- 10** Restoration of Edentulous Maxillae with Fixed Protheses

Section III: Restoration of Partially Edentulous Patients

- 11** Restoration of the Posterior Quadrants of Partially Edentulous Patients: Basic

Principles and Patient Selection

12 Restoration of the Posterior Quadrants:
Examination, Workup, and
Prosthodontic Procedures

13 Restoration of Single-Tooth Defects in
the Esthetic Zone

14 Restoration of Multiple-Tooth Defects in
the Esthetic Zone

Section IV: Special Topics

15 Implants and Removable Partial
Dentures

16 Implants for the Growing Child

17 Implants in Irradiated Tissues,
Osteoporosis Patients, and Patients
Treated with Bisphosphonates

18 Implants and Orthodontics: A Symbiotic Partnership

19 Basic Fundamentals of Implant Surgery

20 Follow-up, Maintenance, Complications, and Troubleshooting

Index



Please scan the QR code to access the illustrated glossary

DEDICATION

To Jan, for her unwavering love and support.

John Beumer III

To my wife, Terry, who continues to love,
support, and believe in me as I continue my
life's endeavors.

Robert F. Faulkner

To my entire family for their love and
encouragement: to my parents, Chimanlal and
Kusum, for always believing in me; to my
siblings, Jigar and Hetal, for their unconditional
support; to my son, Kiaan, and my daughter,
Vachi, for their inspiration to keep trying no
matter what; and last but definitely not least, to
my wife, Shreya, for everything she does and
her love and support.

Kumar C. Shah

To Betty, Chloe, and Sarah for making every
moment a blessing, and to my teachers for
shaping my students.

Benjamin M. Wu

PREFACE

A first edition is always a work in progress, and this is especially true in a field as dynamic as implant prosthodontics. Moreover, dentistry and dental education are in the midst of revolutionary change, primarily because of the refinement of CAD/CAM technologies. These changes are by no means confined to implant prosthodontics. For example, removable partial denture (RPD) metal frameworks designed digitally and printed using selective laser melting now achieve precision and strength equivalent to that produced by the most skilled laboratory technician using analog methods. Fabrication of complete dentures using digital technologies is now possible—although the best outcomes are achieved when time-tested analog impression techniques are combined with digital methods. The digital revolution has allowed us to explore the use of new restorative materials for our implant-borne restorations, to visualize the local anatomy of our patients in three dimensions prior to treatment, and to execute our surgical and prosthodontic treatments with improved precision and efficiency. One of the goals of this new edition is to illustrate when and how digital technologies can be combined with analog techniques to create workable and efficient prosthodontic workflows.

As in the first edition, the book is divided into sections. Several new topics and chapters have been added to the second edition. In chapter 3, a synopsis of biomechanics as it pertains to implant prosthodontics is presented along with our view of the proper approach to occlusal and component design. Where possible, clinical data are

combined with engineering principles to illustrate practical application of biomechanical concepts. Mechanotransduction and tissue response to mechanical loading are included to emphasize the dynamic nature of the bone-implant interface. New chapters on digital technologies and contemporary materials used in implant dentistry have also been added. Issues pertinent to maintenance, implant and prosthodontic complications, and their treatment are combined in another new chapter. The chapter on the use of implants in irradiated tissues has been enhanced to include a section on the use of implants in patients treated with bisphosphonates. Another chapter has been added devoted to implant surgery and tailored for nonsurgically trained dentists.

The impetus for this supplement has been the recent mandate by CODA (Commission on Dental Accreditation of the American Dental Association) to train prosthodontic residents in the basic fundamentals of implant surgery. Furthermore, throughout the book, we have tried to present clinical follow-ups of patients displayed in the first edition, some over 30 years postdelivery.

We continue to emphasize the importance of considering conventional prosthodontic methods and presenting these to the patient. As in the first edition, we indicate when conventional approaches (tooth-supported fixed dental prostheses, RPDs, and restoring diseased teeth with endodontic therapy and conventional restorations) should be considered. Frequently, conventional treatments are just as effective in restoring form and function (and sometimes more so), are more time efficient, and more often than not are more cost effective than implant options.

We continue to believe that most patients are best served with an interdisciplinary effort. Some patients present with relatively simple problems and can be handled

by a solo practitioner (hence, the addition of the chapter devoted to implant surgery for nonsurgically trained dentists). However, most patients present with significant prosthodontic complexities such as occlusal plane discrepancies, malposed teeth and unfavorable jaw relations, periodontal compromise of existing dentition, and significant bone and soft tissue defects associated with the potential implant sites, especially in the esthetic zone. Achieving sustainable outcomes for such patients requires the prosthodontist or restorative dentist to develop close professional interaction with oral and maxillofacial surgeons, periodontists, orthodontists, and endodontists as well as dental technicians and staff associated with biomedical modeling centers.

An important objective of this edition is to reinforce the basic principles of fixed and removable prosthodontics. In order to develop an appropriate level of expertise in implant prosthodontics, the clinician must have a firm foundation in conventional fixed and removable prosthodontics. Therefore, topics such as occlusal schemes used for the various types of implant prostheses, as well as designing proper resistance and retention form into customized abutments where the prosthesis is to be retained with cement, the principles of smile design and esthetics, and other topics pertinent to the fundamentals of prosthodontics are emphasized and discussed as needed.

ACKNOWLEDGMENTS

John Beumer III

As in the first edition, I would like to personally thank my mentors: Dr Sol Silverman Jr, Distinguished Professor of Oral Medicine, University of California, San Francisco (UCSF); Dr Thomas A. Curtis, Professor of Prosthodontics, UCSF, and one of the fathers of modern Maxillofacial Prosthetics; and Dr F. J. Kratochvil, Professor of Prosthodontics, University of California, Los Angeles (UCLA), and the developer of the RPI system of removable partial denture design. They were selfless individuals and wonderful role models who are rightly considered giants in their respective disciplines. Their personal integrity, commitment to excellence, and enthusiasm for education and research has been inspiring for me and many others in our profession. I would also like to thank Dr Henry Cherrick, Professor of Pathology and Dean Emeritus, UCLA School of Dentistry. His friendship and mentorship during my early years at UCLA were invaluable, and his leadership and vision as Dean led to the development of robust education and research programs in implant dentistry at UCLA. Also, his encouragement and support were indispensable to the development of the Jane and Jerry Weintraub Center for Reconstructive Biotechnology, Division of Advanced Prosthodontics, UCLA. Last, I would like to extend my thanks to Mr Hiroake Okabe, CTD, who for 20 years directed our Dental Laboratory and Dental Laboratory School devoted to Implant Prosthodontics. His knowledge of implant prosthodontics was astounding, and a substantial amount of his work and that of his students still

survives in this edition. The quality of the implant program at UCLA was in large measure due to his expertise and commitment to excellence.

Robert F. Faulkner

First and foremost, I dedicate this book to my parents, Bob and Betty Faulkner. My mom's love and encouragement through the years of her life will remain with me and serve as a constant reminder to set goals and to reach for them with all of my being, and my dad has served as an incredible role model and is truly the man I have always admired and aspired to emulate the most. He has continued to believe in my abilities, even when I doubted myself. The completion of this second book was in no small part due to the work ethic that they have instilled in me. To my children, Lauren and Rob, with whom God blessed me, for their love and understanding; I continue to be amazed at the individuals they are becoming and I am honored to be their father. I would also like to acknowledge my coeditors. They dedicated themselves to a level of excellence in compiling this book and are a reflection of the level of commitment that we have strived to achieve in our profession of prosthodontics. There are several other individuals who have shaped my life's journey, and they, too, have given much to develop my path toward the culmination of these books. I would like to express my sincere gratitude to these mentors: Dr Wayne Payne, Professor Emeritus, Ball State University, Department of Health Science and Physiology, whose encouragement allowed the completion of my master's thesis and helped develop an interest in teaching; and Dr Julian Woelfel, Professor Emeritus in Prosthodontics, and Dr Wayne Campagni, Professor Emeritus, The Ohio State University, College of Dentistry, who both guided my early

development in prosthodontics. These two individuals have helped shape many prosthodontists' careers, and it has been my honor to be influenced by their mentorship. Dr Theodore Berg Jr, Professor Emeritus, UCLA School of Dentistry, remains one of my most cherished mentors in prosthodontics. His careful way of teaching and encouraging students to excel was unparalleled, and he has remained an inspiration to me through my years in private practice and continues to be a constant reminder as to the true meaning of being a teacher. Finally, I would like to thank the countless friends and colleagues who have worked with me and have encouraged and been accommodating of my efforts throughout these many years. Without their support, these books would have only been a dream.

Kumar C. Shah

I would like to thank my coeditors for the opportunity to engage with them on this enormous task. Their friendship and support have been invaluable throughout this process. While receiving a strong foundation as a dental student at the National University of Singapore (NUS), Faculty of Dentistry, my initial interest in prosthodontics stemmed from two individuals: Dr Chew Chong Ling and Dr Keson Tan, both Professors at NUS. They both were extremely encouraging in the pursuit of graduate education. Two other individuals had a big impact on my professional life during my residency at The Ohio State University, College of Dentistry—Dr Wayne Campagni and Dr Ernest D. Svensson, Professors Emeritus, The Ohio State University. Their dedication to prosthodontic education and their passion had a great deal of influence on my early career. Their exemplary talents and patience have been a motivation for my career in education. I would also like to

thank Dr Sreenivas Koka for his friendship and mentorship. He has been wonderful as a role model and someone to discuss ideas and concepts to challenge the status quo in dentistry.

Benjamin M. Wu

Words cannot express my deepest appreciation for the selfless generosity of my mentors who opened doors to the world that I know today. Joel Cohen (University of the Pacific) infected me with the research bug, letting me run electrophoretic mobility experiments between casting gold crowns. Colonel Ryle A. Radke (UCSF) stimulated my lifelong devotion to prosthodontics by letting me shadow him. The Harvard prosthodontics faculty taught me the art, science, and limitations of prosthodontics. Edwin J. Riley (Harvard) showed me how to be an innovative prosthodontist and better person (still trying), and encouraged me to try the pilot Harvard/Massachusetts Institute of Technology (MIT) program that Ichiro Nishimura (Harvard) created. The MIT materials science faculty taught me how to think top-down and bottom-up with engineering fundamentals. Michael J. Cima (MIT) taught me how to solve problems with transdisciplinary creativity and scientific rigor, and encouraged me to turn a homemade 3D printer into a doctoral thesis. John Mackenzie (UCLA) recruited me to UCLA Engineering and gave me the once-in-a-lifetime opportunity to build the Department of Bioengineering. Ichiro Nishimura, John Beumer, and the rest of the UCLA Advanced Prosthodontics faculty welcomed me into their renowned division, gave me the key to the Weintraub Center, and allowed me to decorate both with engineering flavor. The journey was made far more meaningful by the countless colleagues, collaborators, students, residents, postdocs, visiting

scholars, technicians, and staff members whose devotion to excellence was most inspiring.

CONTRIBUTORS

Jaafar Abduo, BDS, DCLinDent, PhD

Associate Professor, Restorative Dentistry
Division of Medicine, Dentistry, and Health Sciences
Melbourne Dental School
University of Melbourne
Melbourne, Australia
chapters 3 and 5

Nadim AbouJaoude, DDS, CES, DU

Lecturer
Department of Oral and Maxillofacial Surgery
School of Dentistry
Lebanese University
Private Practice
Beirut, Lebanon
Chapter 18

Basil Al-Amleh, BDS, DCLinDent

Former Senior Lecturer
Discipline of Prosthodontics
Department of Oral Rehabilitation
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
chapters 2, 4, and 5

Momen Atieh, BDS, MSc, DCLinDent, PhD

Chair and Associate Professor

Department of Periodontology
Hamdan Bin Mohammed College of Dental Medicine
Mohammed Bin Rashid University of Medicine and Health
Sciences
Dubai, United Arab Emirates

Honorary Associate Professor
Sir John Walsh Research Institute
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
chapters 2 and 20

Nabil J. Barakat, DDS, MS

Professor Emeritus and Chair
Department of Oral and Maxillofacial Surgery
School of Dentistry
Lebanese University

Private Practice
Beirut, Lebanon
Chapter 18

Abdullah Barazanchi, BDS, DCLinDent

Senior Lecturer
Discipline of Prosthodontics
Department of Oral Rehabilitation
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
Chapter 4

John Beumer III, DDS, MS

Distinguished Professor Emeritus

Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
chapters 1, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, and 20

Ting-Ling Chang, DDS

Clinical Professor
Chair, Section of Prosthodontics
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Chapter 15

Aria Davodi, DDS

Lecturer
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Private Practice
Beverly Hills, California
chapters 9 and 10

Moustafa El-Ghareeb, DDS, MS*

Assistant Clinical Professor
Section of Oral and Maxillofacial Surgery
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Chapter 19

Mauro Farella, DDS, PhD

Professor and Head
Discipline of Orthodontics
Department of Oral Sciences
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
Chapter 18

Robert F. Faulkner, DDS, MS

Lecturer
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Private Practice
Cincinnati, Ohio
chapters 1, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, and 20

Fiona Firth, BDS, DClinDent

Senior Lecturer
Discipline of Orthodontics
Department of Oral Sciences
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
Chapter 18

Neal Garrett, PhD

Professor Emeritus
Division of Advanced Prosthodontics
School of Dentistry

University of California, Los Angeles
Los Angeles, California
Chapter 6

Suzanne M. Hanlin, MDS

Senior Lecturer
Discipline of Prosthodontics
Department of Oral Rehabilitation
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
Chapter 7

Jay Jayanetti, DDS

Assistant Clinical Professor
Director, Maxillofacial Prosthetics
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Chapter 9

Nora Kahenasa, DDS

Lecturer
Section of Oral and Maxillofacial Surgery
School of Dentistry
University of California, Los Angeles
Private Practice
Los Angeles, California
Chapter 17

Haim Keren, CDT, MDT

Kerenor Dental Studio
Montreal, Canada
Chapter 8

Julia Keren, CDT

Kerenor Dental Studio
Montreal, Canada
Chapter 8

Mohamed Moataz Khamis, BDS, MS, PhD

Professor and Chairman
Department of Prosthodontics
Director of the Comprehensive Dental Implant Certificate
Program
Director of the Clinical Master of Oral Implantology
Program
Faculty of Dentistry
Alexandria University
Alexandria, Egypt
chapters 12 and 13

Perry R. Klokkevold, DDS

Clinical Professor
Director of the Graduate Program in Periodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Chapter 19

David Krill, DMD

Private Practice
Cincinnati, Ohio
Chapter 20

Kai Chun Li, BDentTech, PhD

Senior Lecturer, Biomaterials
Department of Oral Rehabilitation
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
Chapter 4

Robert M. Love, ONZM, BDS, MDS, PhD

Professor and Dean
School of Dentistry and Oral Health
Griffith Health Center
Griffith University
Southport, Australia
Chapter 11

Karl M. Lyons, BDS, MDS, PhD

Professor and Chair in Restorative Dentistry
Department of Oral Rehabilitation
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
chapters 3, 4, 5, 6, 7, 9, and 17

Sunyoung Ma, BDS, DClinDent, PhD

Associate Professor, Prosthodontics
Department of Oral Rehabilitation
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
chapters 6 and 7

Ichiro Nishimura, DDS, PhD

Professor

Division of Advanced Prosthodontics and Oral Biology and
Medicine

School of Dentistry

Affiliate Professor

Department of Bioengineering

Samueli School of Engineering

University of California, Los Angeles

Los Angeles, California

chapters 2 and 6

Takahiro Ogawa, DDS, PhD

Professor

Division of Advanced Prosthodontics

School of Dentistry

University of California, Los Angeles

Los Angeles, California

Chapter 2

Daniela Orellana, DDS, MS

Assistant Clinical Professor

Division of Advanced Prosthodontics

School of Dentistry

University of California, Los Angeles

Los Angeles, California

chapters 7, 9, and 15

Alessandro Pozzi, DDS, PhD

Adjunct Associate Professor

Goldstein Center for Esthetic and Implant Dentistry

Department of Restorative Sciences

Dental College of Georgia

Augusta University
Augusta, Georgia

International Center for Oral Rehabilitation
Rome, Italy
Chapter 10

Roy Sabri, DMD

Clinical Associate
American University of Beirut Medical Center

Private Practice
Beirut, Lebanon
Chapter 18

Donald R. Schwass, BDS, DCLinDent

Clinical Director
Faculty of Dentistry
University of Otago
Dunedin, New Zealand
Chapter 3

Pravej Serichetaphongse, DDS, MS

Associate Professor
Department of Prosthodontics
Chair of the Esthetic Implant Program
Head of the Maxillofacial Prosthetics Unit
Faculty of Dentistry
Chulalongkorn University
Bangkok, Thailand
chapters 3, 12, and 13

Kumar C. Shah, BDS, MS

Professor of Clinical Dentistry
Director of Residency in Advanced Prosthodontics
Division of Advanced Prosthodontics
University of California, Los Angeles
Los Angeles, California
chapters 1, 3, 4, 5, 8, 11, 12, 14, and 19

Arun B. Sharma, BDS, MSc

Clinical Professor of Health Sciences
Director of Graduate Prosthodontics
Division of Preventive and Restorative Sciences
School of Dentistry
University of California, San Francisco
San Francisco, California
Chapter 16

Eric Sung, DDS

Professor of Clinical Dentistry
Vice Chair
Division of Advanced Prosthodontics
School of Dentistry
University of California, Los Angeles
Los Angeles, California
Chapter 17

Andrew Tawse-Smith, DDS, CPerio, PhD

Associate Professor, Periodontics
Associate Dean, International
Department of Oral Sciences
Faculty of Dentistry
University of Otago
Dunedin, New Zealand

chapters 2 and 20

Darryl C. Tong, BDS, MBChB, MSD, PhD

Professor of Oral and Maxillofacial Surgery

Head of the Department of Oral Diagnostic and Surgical
Sciences

Faculty of Dentistry

University of Otago

Dunedin, New Zealand

Chapter 17

Neil Waddell, HDE, PGDipCDTech, MDipTech, PhD

Professor and Head

Discipline of Biomaterials

Department of Oral Rehabilitation

Faculty of Dentistry

University of Otago

Dunedin, New Zealand

Chapter 4

Chandur Wadhvani, BDS, MSD

Affiliate Assistant Professor

Department of Restorative Dentistry

School of Dentistry

University of Washington

Seattle, Washington

Private Practice

Bellevue, Washington

chapters 12, 13, and 14

Benjamin M. Wu, DDS, PhD

Professor and Chair