CLINICAL AND LABORATORY MANUAL OF DENTAL IMPLANT ABUTMENTS
Contents

LIST OF CONTRIBUTORS, vii
FOREWORDS, viii
PREFACE, xi
DEDICATIONS, xii

1 Implant Abutment Materials, 1
Hamid R. Shafie and Bryan A. White
Introduction, 1
Mucosal Seal, 1
Pellicle, Biofilm, and Periodontal Disease, 2
Implant Abutment Material Related Research, 3
Conclusions, 14
References and Additional Reading, 14

2 General Information about Implant Abutments, 17
Hamid R. Shafie
Terminology, 17
Stock Abutments, 17
Customized Abutments, 20
References and Additional Reading, 22

3 Retaining Abutment Screws, 23
Hamid R. Shafie and Scott Martyna
Introduction, 23
Basic Terminology, 23
Abutment Screw Mechanics, 24
Abutment Screw Materials, 25
Special Considerations, 26
Abutment Screw Failure, 28
References and Additional Reading, 32

4 Different Implant–Abutment Connections, 33
Hamid R. Shafie and Bryan A. White
Introduction, 33
Chronological Development of Abutment Connections, 33
External Hex Connections, 34
Internal Connections, 35
Comparison of Different Internal Connection Designs, 37
Conclusions, 43
References and Additional Reading, 44

5 Prefabricated Implant Abutments, 47
Paul P. Binon
Introduction, 47
Chronological Development of Prefabricated Abutments, 47
Examples of Prefabricated Abutments, 49
Clinical Examples, 54
References and Additional Reading, 63

6 Use of CAD/CAM Technology in Custom Abutment Manufacturing, 65
Julian Osorio and Robert B. Kerstein
History of CAD/CAM Technology in Prosthetic Dentistry, 65
History of CAD/CAM Technology in Implant Abutment Manufacturing, 66
Virtual Design and Manufacture of Abutments, 69
Abutment Placement Using Sulcular Stretching, 82
Clinical Examples, 86
Advantages of CAD/CAM Abutments Versus Regular Cast Custom Abutments, 97
Common Problems in CAD/CAM Abutment Manufacturing, 99
Conclusions, 100
References and Additional Reading, 100

7 Relationship between Abutment Geometry and Peri-implant Tissue in Esthetic Zone Cases, 102
Dean Morton, Tamer Abdel-Azim, and Wei-Shao Lin
Introduction, 102
Provisional Restorations Prior to Implant Loading, 103
Contouring the Soft Tissue with Provisional and Custom Impressions, 107
Different Designs of Final Crowns Supported by Custom and Stock Abutments, 111
References and Additional Reading, 121

8 Instrumentation for Abutment Modification and Guidelines for their Use, 122
Hamid R. Shafie
Introduction, 122
Extra-Oral Adjustment Techniques for a Titanium Abutment, 122
Extra-Oral Adjustment Techniques for a Zirconia Abutment, 125
Intra-Oral Adjustment Techniques FOR a Zirconia Abutment, 128
References and Further Reading, 132

9 Abutment Preparation Techniques for One-Piece Titanium and Zirconia Implants, 133
Hamid R. Shafie and Mary L. Ballard
Introduction, 133
Material Science of One-Piece Implants, 136
One-Piece Implant Macro-Geometry, 138
One-Piece Implant Micro-Geometry, 142
Case Selection Criteria, 143
Surgical Techniques, 148
One-Piece Implant Abutment Preparation Techniques, 163
Principles of Loading, 170
Provisionalization and Crown Fabrication, 171
References and Additional Reading, 175

10 Cleaning, Disinfection, and Sterilization Techniques for Implant Abutments, 177
Hamid R. Shafie
Introduction, 177
Cleaning, Disinfecting, and Sterilizing Implant Abutments, 177
Cleaning and Sterilizing Abutment Adjustment Instruments, 178
References and Additional Reading, 179

INDEX, 181
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Forewords

With implant dentistry going through such rapid changes over the past few years it is very timely to see a textbook on the latest technology related to implant abutments. Hamid Shafie is to be congratulated for putting together a much needed update of all clinical and laboratory aspects of dental implant abutments. The book is filled with information and references related to different types of abutments, their shapes, the materials used, and the types of connections that are available. In addition, there are chapters on screw technology and abutment materials that are up to date and excellent for both the beginner and the advanced reader. The chapter on CAD-CAM technology is particularly useful as so many clinicians today are using these techniques. The chapters are also filled with excellent diagrams and clinical examples that clearly make the point of the pros and cons of different abutments.

It is a pleasure to see this fine book come to print. It will be a staple in every clinician’s and technician’s reference library. Congratulations to Dr Shafie and his co-authors for a job well done.

Dennis Tarnow, DDS
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The biologic adaptation of soft and hard tissues is omnipotent when considering the surface treatments and the construction of the prosthesis. Platform switching is nicely demonstrated and the Laser-Loc system, to gain optimal collagen attachment to the abutment, is presented. The physical perpendicular attachment of the fibers prevent the apical migration of the epithelium and, thus, offer protection of the crestal bone. Platform switching has been very effective in curtailing the micro-gap issue resulting in the loss of 1.5–2 mm of crestal bone as the result of an inflammatory infiltrate.

This information will simplify a confusing decision where there is a paucity of agreement relative to the selection of abutment. The topic of esthetics is so very important to the patient that it mandates considerable space. The answers are well presented by both text and illustrations and can be converted to optimal patient treatments.

I suggest this book will be of great value to all dentists who seek perfection in their implant endeavors. It should find a place in every office.

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The restorative realm of implant dentistry has become increasingly sophisticated in recent years but simultaneously it has become progressively more complex, complicated and convoluted for the practicing clinician.

Fortunately, Dr. Hamid Shafie has correlated vast amounts of data and information, synthesized it and delivered it to us all in a clinically relevant text. The *Clinical and Laboratory Manual of Dental Implant Abutments* is an invaluable, complete, yet concise text that addresses all aspects of restorative implant dentistry from material selection, through pre-fabricated and custom abutments, and today, the relevance of CAD/CAM manufacturing.

It also covers the key facets of the retaining abutment screw, the biology and mechanics of the different abutment-implant connections, and that consummate evaluative signature of success, the peri-implant soft tissue.

“Digital Dentistry” has had a particularly large impact on the dental implant arena, diagnostically, clinically, and in the rapidly evolving aspect of implant abutments.

Even though sophisticated implant dentistry has been in existence for over a quarter century, the technology continues to advance. The application of implant borne restorations to more diverse and demanding applications has further complicated this field. The emphasis on comprehensive treatment planning including biomechanics, esthetics, and bone maintenance by mechanotransduction, and restorative material attributes, all flow through the myriad of abutment configurations. This comprehensive manual by Dr. Shafie provides an excellent didactic, and visual source of information for every approach and type of implant connection. Importantly it explains material properties and applications, as well as the biological response to the various configurations and parts. This manual will serve us all as the ultimate guide to decision making, and implementation, of abutment rendered implant prosthetics.

3D technologies now facilitate every element of this restorative realm from the diagnosis and initial strategies, through the surgical phases, to the final design and fabrication of the ensuing prosthesis.

This makes the entire implant process easier, more predictable, economically viable, and so available to a greater percentage of the world’s population.

Hopefully this text, like Dr. Shafie’s previous one, will also be translated into multiple languages and so go on to similarly advance the global clinical possibilities and then reality of implant dentistry for more and more of the world population.

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There is an increasing need for the oral and maxillofacial surgeon to understand the intricate details of restorative implant dentistry. For the past 10 years, implant manufactures have focused more on design and technology development of abutments than the implant screw itself. CAD/CAM abutments, zirconia abutments, and Laser-Lok™ abutments are a few examples of those advancements. With such a dynamic market, many implant companies are glad to hype the superiority of their different implant abutment connection designs.

Making a crown and cementing it over an abutment is a simple procedure for any dentist. Placing an implant is a simple procedure for any surgeon. The confusion comes from the important intermediate part called the abutment. It is no longer sufficient to just perform precise surgery, since choosing the wrong abutment will most likely lead to implant failure.

While up to now we have had to rely on multiple sources for a discussion on this topic, it is refreshing to find a book that is a concise source of information about implant abutments. This book gives an independent, objective overview of different connection designs and their impact on the crestal bone and eventually on the outcome of treatment. It has the format of a cookbook with lots of illustrations and detailed instructions.

Dr Shafie has considerable experience not just as a prosthodontist but also as an educator of generations of oral and maxillofacial surgery residents in our Department. As a prosthodontist for the past 20 years, he has tried to bridge the gap between surgeons and restorative dentists. The first breakthrough was his overdenture textbook, which was well received globally, and is now complemented by this excellent book following the same vision. In essence, oral surgeons cannot be successful in implant dentistry unless they have full knowledge of the restorative aspects of treatment. Implant dentistry is changing and shifting toward a full service concept. With this perspective, Dr Shafie has produced a unique book of great practicality to oral surgery residents in training as well as to established specialists who want to educate themselves about restorative aspects of implant dentistry.

It is with great pleasure that I recommend this book, which should be essential in the library of all oral surgeons involved in implant dentistry.

George Obeid, DDS
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Almost 40 years after the introduction of osseointegration, and after countless scientific publications by many talented dentists from around the world, I am delighted to present this unique textbook to everybody who is involved in implant dentistry. The subject of implant abutments was previously often simplified and overlooked, or subsumed within bigger clinical subjects and techniques.

A common misunderstanding in implant dentistry is that one type of abutment is suitable in multiple situations. Those who strive for the best implant treatment results for their patients understand that choosing an abutment is not a one-size-fits-all approach. Choosing the correct abutment is integral to achieving a mechanically stable and esthetically pleasing restoration.

This book follows the same format as my first textbook. It is rich with photos, illustrations, and tables. It discusses the details of available abutment materials, types, and components, and gives the clinician the tools to select the appropriate abutment in any clinical situation. Also reviewed are common pitfalls related to abutment choices and failures. All the contributors undertook an extensive literature review to insure each chapter includes the most important references and key articles by other clinicians and scholars.

I had the privilege of working with nine talented clinicians with superior academic backgrounds, who accepted my invitation to share their knowledge and expertise. This book will be a great reference for our colleagues in private practice as it shows step by step how to perform the different treatments. Hopefully educators and key opinion leaders in the field of implant dentistry will also use and recommend this valuable reference to residents and students.

Many thanks to my publisher, Wiley Blackwell, for endless patience, kindness, and most of all giving me encouragement to write another book. I would like to acknowledge and thank my friend and assistant Larisa Zgircha, who coordinated the entire text and images, and Mike Chapman, who is one of the most talented medical illustrators in the dental field and spent countless hours designing the cover of this book to make sure it reflects the heart and soul of what we have written. I cannot thank him enough for his support. Finally, I would like acknowledge all the major implant companies in the world that extended their unconditional support to me and all of the contributors.

Hamid R. Shafie
Washington DC, 2014
With love to my wife, Maryam and daughter, Ava for being so understanding and supportive while I was working on this book.

To my parents, Mehdi and Minoo who gave me everything I needed to advance in life.

To my wonderful readers… your positive response to my first book motivated me to write this one. “Writing a textbook is like a chef preparing a fine dining experience. All of my preparations and efforts are for enjoyment of the readers. Knowing that somebody enjoyed the experience and shared it with others is the best reward for an author.”

To my mentor and friend George Obeid. A man who gave me the best opportunity in my professional life and helped me to realize my dream. I remain grateful forever.
1

Implant Abutment Materials

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INTRODUCTION

A wide variety of abutment materials are available on the dental implant market. A major challenge for clinicians today is understanding the biologic response to each material, as well as the best indication for using each of the different types.

To complicate this problem, there are no well defined and comprehensive sources reviewing the properties associated with abutment materials. This chapter provides relevant information on abutment materials and their soft tissue response.

MUCOSAL SEAL

The mucosal seal surrounding a dental implant abutment is an essential factor in preventing bacterial penetration into the crestal bone and around the implant neck. In order to understand the soft tissue response, it is important to be familiar with the anatomy of the mucosal seal.

Natural Dentition

The periodontal soft tissue is an important factor in a person’s natural protection against periodontal disease. The biologic width is the depth of soft tissue below the sulcus in the natural dentition. It consists of a junctional epithelium and connective tissue layer. The junctional epithelium ranges from 1 to 2 mm wide followed apically by a 1 mm layer of connective tissue. The alveolar bone lies just below this connective tissue.

In the natural dentition, this zone has been proven to be essential for protecting the periodontium from plaque and bacteria penetration into the oral cavity. The junctional epithelium attaches to the teeth with a hemidesmismosal attachment, providing a shield against bacteria. The connective tissue layer contains collagen fibers that insert into the teeth and cementum perpendicularly to the tooth. These fibers provide additional reinforcement against an apically migrating junctional epithelium caused by periodontal disease.

Peri-implant Mucosal Seal

A mucosal seal surrounding dental implants is also essential in avoiding peri-implantitis. The biologic width surrounding dental implants also contains a junctional epithelium, followed apically by a connective tissue layer. As in the natural dentition, the coronal portion of the biologic width contains the junctional epithelium. In 1984, Gould and colleagues demonstrated that this junctional epithelium attaches to the titanium surface in a similar manner to the natural dentition, with hemidesmosomes. A connective tissue attachment can be found further apically. Buser et al. (1992) described this attachment as being rich in collagen fibers but sparse in cells or resembling scar tissue.
The process of plaque formation begins with glycoproteins attaching to the surface of the enamel or an abutment, creating a thin layer called the pellicle. Although this layer by itself is harmless, it provides a framework for bacteria to adhere to.

**Biofilm**

A biofilm is an aggregation of multiple organisms coexisting together. Initially, Gram-positive aerobic cocci adhere to this thin glycoprotein layer or pellicle. As these bacteria multiply, the bacterial colonies multiply creating a more anaerobic environment. This anaerobic environment then permits more harmful Gram-negative rods to collect within the biofilm. The biofilm creates an acidic environment that contributes to dental caries but, more relevant to the topic at hand, the biofilm also contributes to periodontal disease.

**Pellicle**

Unlike the natural dentition, in implant abutments the apical connective tissue fibers do not have the same quality of attachments. The natural dentition has dentogingival fibers running perpendicular to the tooth from the bone to the cementum. The connective tissue layer surrounding a dental implant abutment has fibers running in a parallel fashion (Figure 1.1). The only exception to this histology is with Laser-Lok™ abutments which are discussed later in this chapter.

Due to the weakened connective tissue support around implant abutments, the junctional epithelium is believed to be more susceptible to apical migration. In other words, a dental implant is more susceptible to peri-implantitis than a natural tooth is to periodontitis.

It is important to note that this biologic width or “peri-implant seal” protects the implant against peri-implantitis and provides an esthetic result. When considering which abutment type to use one should consider how well the abutment forms and maintains this mucosal seal.

**PELLICLE, BIOFILM, AND PERIODONTAL DISEASE**

One of the key factors in selecting an abutment material is its hygienic property. To review the importance of hygiene it is important to understand pellicle formation, subsequent biofilm production, and the pathway of peri-implantitis development.

**Figure 1.1** Note the perpendicular collagen fibers in the natural dentition (a) and Laser-Lok abutments (c) in comparison to the parallel collagen fibers with other implant abutments (b).

**Periodontal Disease in the Natural Dentition**

Periodontal disease is caused by the biofilm, which destroys the periodontium and causes loss of the alveolar bone and inflammation of the periodontal tissues. This is not a novel development – the landmark paper by Page and Schroeder outlined this process of periodontal disease back in 1976.
**Peri-implantitis**

As in the natural dentition, development of the pellicle and biofilm and subsequent inflammation also occurs with dental implants. This process can cause the potential for apical migration of the peri-implant seal and bone loss. The process of peri-implantitis is more common with dental implants than periodontal disease is with natural dentition. This is because the peri-implant mucosal seal is not as effective (except in the case of Laser-Lok abutments) as the mucosal seal surrounding the natural dentition.

As will be discussed, some abutments have enhanced capabilities for resisting bacterial colonization. Other abutments have improved capabilities for forming a more resistant mucosal seal with a strengthened connective tissue attachment.

**IMPLANT ABUTMENT MATERIAL RELATED RESEARCH**

The remainder of this chapter focuses on the variety of abutments available on the market. Different abutment materials will be compared in terms of their ability to form and maintain the “peri-implant seal.” Carefully chosen research has been selected to demonstrate how the varieties of abutments specifically affect soft tissue.

The most commonly used implant abutment materials (Figure 1.2, Table 1.1) to be discussed are:

- Titanium:
  - machined
  - polished
  - Laser-Lok.
- Surgical grade stainless steel.
- Cast gold.
- Zirconia.
- Polyether ether ketone (PEEK).

**Titanium**

**Physical properties**

Titanium is the only element that offers the unique combination of strength, light weight, and biocompatibility, as well as being extremely durable and strong. Titanium has high corrosion resistant and the highest strength to weight ratio of any known element (Figure 1.3).

Titanium abutments are either made of commercially pure titanium or titanium alloy.

*Commercially pure titanium* Commercially pure (CP) titanium is widely utilized for medical applications because of its corrosion resistant, high strength, and biocompatible applications. The mechanical properties of CP titanium are influenced by small additions of oxygen and iron. By careful control of these additions, the various grades of CP titanium are produced to give properties suited to different applications. CP titanium with the lowest oxygen and iron levels makes the most formable grade of material; while progressively higher oxygen content results in higher strength levels.

**Table 1.1** Abutment materials and soft tissue response

<table>
<thead>
<tr>
<th>Abutment material</th>
<th>Forming the peri-implant seal</th>
<th>Maintaining the peri-implant seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium (machined or polished)</td>
<td>Long-term studies supporting favorable soft tissue results with machined or polished titanium.</td>
<td>Long-term studies supporting favorable soft tissue maintenance with machined or polished titanium. Most validated abutment material in the literature</td>
</tr>
<tr>
<td>Titanium abutments with a Laser-Lok transmucosal collar</td>
<td>Greatest ability to form a connective tissue attachment compared with all other abutment materials on the market</td>
<td>Strongest peri-implant seal permitting improved long-term soft tissue maintenance (comparable mucosal seal to the natural dentition)</td>
</tr>
<tr>
<td>Gold</td>
<td>Conflicting studies in the literature concerning the ability to form an adequate peri-implant seal</td>
<td>Conflicting studies concerning the long-term maintenance of the peri-implant seal</td>
</tr>
<tr>
<td>PEEK (polyether ether ketone)</td>
<td>Comparable soft tissue results to titanium</td>
<td>Comparable hygienic properties to titanium</td>
</tr>
<tr>
<td>Zirconia</td>
<td>Comparable ability to form a peri-implant seal to that of machined or polished titanium</td>
<td>Most hygienic abutment on the market allowing improved long-term maintenance of the peri-implant seal</td>
</tr>
</tbody>
</table>

**Figure 1.2** Different types of abutments made of different materials by Dentsply Implants.
There is an extensive literature validating the favorable soft tissue response with titanium abutments. Because the majority of the research about peri-implant tissue and abutment materials is based on titanium abutment, this material has become a reference point in describing the properties of other abutment materials.

**Machined versus polished titanium and soft tissue responses**

Surface roughness is the key difference between machined and polished titanium. This section evaluates whether there is a clinically significant difference between the soft tissue response to polished and machined titanium.

The breakdown of the peri-implant seal is brought on by the development of a pellicle, biofilm, and inflammation followed by alveolar bone loss. It is well established that the initial glycoproteins and biofilm are more likely to attach to a rough surface than a smooth one. With this logic it could be wrongly assumed that abutments with a smoother surface have less inflammatory response, thus less bone resorption. However, multiple clinical studies have failed to show a clinically significant relationship between an inflammatory response and a roughened abutment surface.

To provide one of many examples, Zitzmann’s study concluded that there was no relation between inflammatory response and the abutment surface roughness (Abrahamsson et al. 2002).

**Zitzmann’s study on the differences in soft tissue response with smooth and rough abutments**

- This study used four implants into the premolar regions of five separate beagle dogs
- After 3 months abutments roughened with acid etching and smoother abutments with a turned surface characteristic were placed
- Six months later biopsies of the implants and the surrounding soft and hard tissues were obtained
- No significant differences were noted between the soft tissue attachments near the rough and smooth abutments

In conclusion, although it has been shown that bacteria are more likely to aggregate on a roughened surface, clinical studies between titanium abutments on the market fail to show this relationship. There is no clinically significant different soft tissue response to machined and polished titanium.
Figure 1.3 The location of titanium on the periodic table.
Prefabribcated abutments with a Laser-Lok surface characteristic are a new innovative product (Figure 1.7). The Laser-Lok consists of 8–12 micron titanium micro-channels. These micro-channels provide the following advantages:

- They enhance the establishment of a connective tissue attachment.
- They inhibit the apical migration of the junctional epithelium.
- They preserve the crestal bone.

Nevins et al.’s study on soft tissue healing using Laser-Lok

- A prospective preclinical trial using a canine model to compare Laser-Lok abutments to machined titanium abutment surfaces
- The study confirmed that the Laser-Lok abutments inhibited the apical migration of the junctional epithelium, prevented coronal resorption, and provided a connective tissue attachment
- On histologic examination the Laser-Lok design provided healing in a similar fashion to the natural dentition. The connective tissue fibers healed perpendicular to the abutment surface demonstrating the rationale behind Laser-Lok’s favorable soft tissue maintenance

With all other implant abutments on the market, connective tissue forms in a weakened parallel fashion to the abutment. The Laser-Lok technology enables the formation of an improved mucosal seal similar to the natural dentition, thus giving it a bright future.

Surgical Grade Stainless Steel

Surgical stainless steel is a specific type of stainless steel used in medical applications, and includes alloying elements of chromium, nickel, and molybdenum. The chromium gives the metal its scratch resistance and corrosion resistance. The nickel provides a smooth and polished finish. The molybdenum gives greater hardness and helps maintain a cutting edge.

Stainless steel is easy to clean and sterilize, strong, and corrosion resistant. Nickel/chrome/molybdenum alloys are sometimes used for implant abutments, but immune system reaction to nickel is a potential complication. Surgical grade stainless steel can be used for temporary implant abutments but is not an ideal material of choice for permanent implant abutment.
**Cast Gold**

Implant manufacturers recognized the limitations of early “stock abutments” and developed a castable abutment called a UCLA abutment. This abutment is comprised of a machined-fit gold alloy base that fits to the corresponding implant head, combined with a plastic sleeve which can be cut, modified, and added to with wax prior to casting into gold (Figure 1.8).

Cast gold abutments were used to fabricate implant-level, custom-cast restorations that provided subgingival margins for esthetics, reduced height for vertical occlusal clearance, and/or custom angles. Cast gold abutments were popular during 1980s and 1990s but with the introduction of more sophisticated stock abutments and CAD/CAM milled abutments they have lost popularity.

- **Gold specs:** 60–65% gold, 20–25% palladium, 19% platinum, and 1% iridium (not a ceramic alloy).
- **Melting range:** Solid, 1400°C; liquid, 1490°C.
- **Recommended casting alloys:** High palladium or high noble porcelain fusing alloys or type III or type IV high noble dental alloys.

Generally, a plastic UCLA abutment is waxed up and customized to an ideal geometry and shape. After investing, the wax and plastic UCLA are burned out of the pattern following the lost wax process. When molten alloy is cast into the investment mold, the gold base component of the UCLA abutment is incorporated into the casting and provides a machined interface that precisely fits the implant. The gold base is fabricated from a non-oxidizing alloy that promotes chemical adhesion of the cast alloy, but does not permit the adhesion of porcelain.

**Relevant Studies Comparing Gold, Porcelain, Titanium, and Aluminum**

Since the late 1990s there has been a consensus that gold and porcelain have a worse soft tissue response