THE IMMEDIACY CONCEPT

Treatment Planning from Analog to Digital

Edited by

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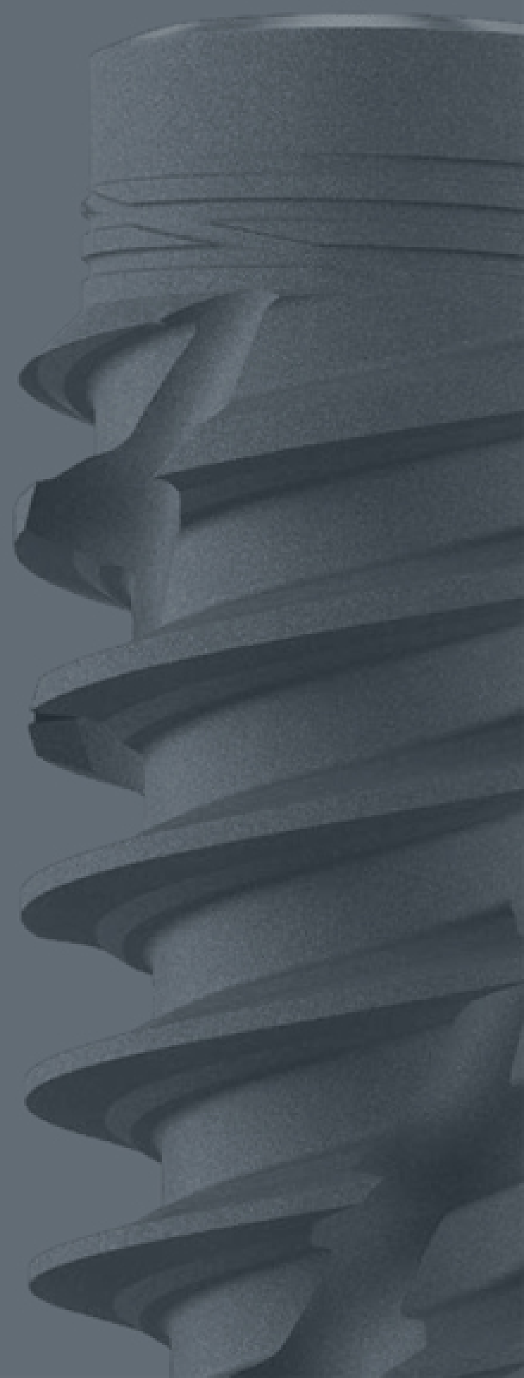
with foreword by Daniel Buser, DDS, Dr med dent



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The Immediacy Concept: *Treatment Planning from Analog to Digital*

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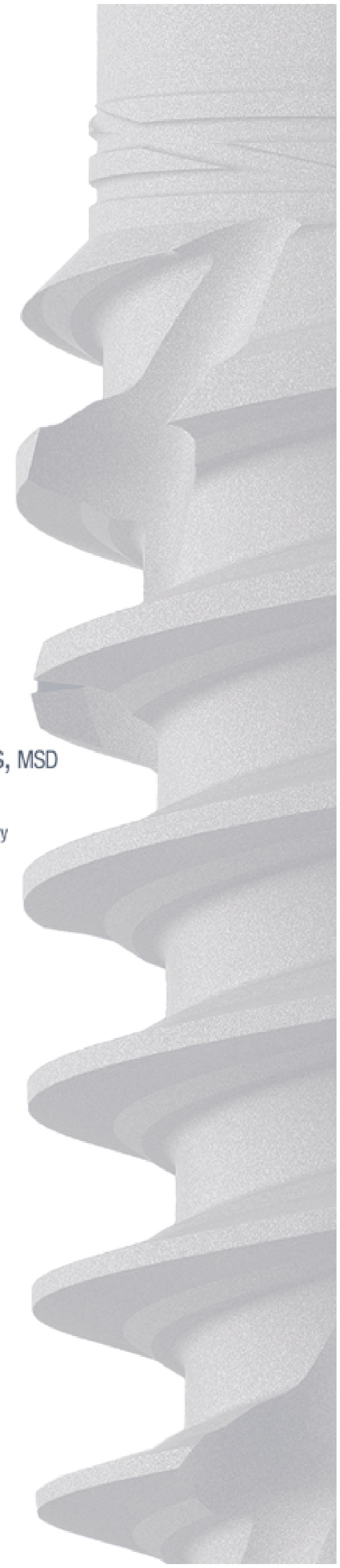

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Contents

Foreword

In the past 50 years, modern implant dentistry—based on the concept of osseointegration—has made tremendous and constant progress to the benefit of patients. Osseointegration was first described by the two research groups of Prof P-I Brånemark from the University of Gothenburg and Prof André Schroeder from the University of Bern. In the 1980s and 1990s, the basic surgical principles were defined, the clinical indications expanded from fully edentulous to partially edentulous patients, the submerged versus nonsubmerged healing modalities were examined, and new microrough implant surfaces were tested, which initiated a paradigm shift in the dental implant market.

Since the millennium change, we have been in a phase of routine application of dental implants. In the past 20 years, many efforts have been made to improve the attractiveness of implant therapy for patients by reducing the surgical invasiveness, pain and morbidity, and healing and treatment periods required. Various placement protocols with immediate, early, and late implant placement postextraction were defined at an ITI Consensus Conference in 2003. In addition, the different loading protocols with immediate, early, and conventional loading and restoration were defined 5 years later.

The present textbook is edited by Dr Edmond Bedrossian, a gifted oral and maxillofacial surgeon and very experienced implant specialist. He was able to invite additional talented authors for contributions to the book, resulting in an excellent and very comprehensive textbook on the concept of immediacy. The first two chapters present the biologic basis of this concept, followed by relevant implant design aspects and biomechanical principles in chapters 3 and 4. Chapter 5 discusses the concept of nonsubmerged tissue-level implants, including the latest development with the TLX implant (Straumann). Chapters 6 to 9 then present the latest developments of the digital workflow in various clinical situations, which has had a tremendous positive impact for these implant treatments. The second half of the book deals with the treatment of fully edentulous patients, in particular the edentulous maxilla, where the immediate loading protocol is a tremendous service for patients for obvious reasons. The book then concludes with case presentations on all clinical situations described throughout to showcase everything that has been learned and how it can be applied.

The clinical chapters clearly show not only the great progress made with these treatment modalities, but also that these treatments are challenging for the clinician and complex in nature. Therefore, these procedures should only be carried out by skilled and experienced implant surgeons. Besides that, case selection based on well-defined selection criteria is very important to select the most appropriate treatment option in a given situation.

In conclusion, this is an excellent, clinically oriented textbook about the concept of immediacy in implant dentistry, and the reader will highly profit from the content. I congratulate Dr Edmond Bedrossian and the other authors. This book can be highly recommended to colleagues with an interest in this topic.

Daniel Buser, DMD, Dr med dent
Prof Emeritus, University of Bern

Preface

"Preservation is more predictable than reconstruction."

The emphasis of this book is that the preservation of alveolar hard and soft tissues is more predictable using the immediacy concept than is the reconstruction of the hard and soft tissues using the traditional delayed approach. Implant treatment is the most physiologic treatment offered to patients missing a single tooth, several teeth, and even their entire dentition. Internal loading of the alveolar bone with an implant-supported prosthesis maintains the alveolar bone volume after loss of teeth.

Treatment of patients with missing teeth has evolved over the past three decades from two-stage delayed loading of implants placed in healed extraction sites to immediate implant placement with immediate provisional restoration placement at the time the teeth are removed. On the other hand, the rehabilitations of the terminal dentition patient and the existing fully edentulous patient have also evolved from delayed placement and delayed loading to immediate placement, which can be performed both in the maxilla and the mandible. What was the motivation for this dramatic change?

- Improved patient comfort and satisfaction
- Shortened treatment time
- Greater treatment acceptance

The vast body of published literature on this subject has allowed for many systematic reviews that clearly support immediate implant placement, fabrication of immediate provisionals, and immediate loading in appropriate clinical settings. Even in extreme cases of alveolar resorption, immediate implant placement with the use of tilted and/or zygomatic implants for the rehabilitation of the edentulous maxilla with a fixed prosthesis has also demonstrated success rates of over 97%. These published success rates are consistent with the 97% to 98% success rate expected with the traditional two-stage delayed loading protocols.

This book presents up-to-date information from discussion of the fundamental (analog) prosthetic and surgical treatment planning protocols to the integration and use of available digital workflows that complement everyday clinical practice. I am confident that readers will appreciate the journey through this book. The authors of every chapter underscore the fundamental scientific facts essential for predictable treatment planning with the practical presentation of clinical protocols for positive short- and long-term outcomes. This patient-centric approach results in the most contemporary and up-to-date information for our colleagues and their patients in every single chapter. The first chapter begins with a comprehensive discussion of distance and contact osteogenesis. Later chapters present the implant micro and macro design features necessary for achieving immediacy. Fundamental analog surgical as well as prosthetic protocols are presented in subsequent chapters. The role of the digital workflow is comprehensively discussed, and its use for the treatment of missing single to fully edentulous cases is presented through the remaining chapters. The final chapters illustrate multiple case reports utilizing and executing the information learned in previous chapters.

Prof P-I Brånemark's sentiment stands true today as it did the day he stated it:

"No one should die with their teeth in a glass of water."

The chapters written by leaders in the field of implant dentistry intend to follow the simple but powerful objectives set by Prof Brånemark, which include interdisciplinary collaboration, simplification, and following science with well-established treatment planning and protocols. The messages from each of Prof Brånemark's objectives are as follows:

Interdisciplinary collaboration between the implant team, the restorative dentist, the surgeon, and the laboratory technician is critical in proper treatment planning, execution of plans, and the long-term maintenance of implant reconstructions. In cases of patients with congenital and/or acquired maxillofacial defects, collaboration with our medical colleagues is also vital.

Simplification refers to the comprehensive understanding of a subject or a procedure. In order to discuss a subject or to execute a procedure and have others respond by saying, "You make it look simple," the complete command of the subject or the procedure is necessary. Knowing the level of predictable outcomes by proper preoperative clinical evaluation and treatment planning leads to practical and predictable prognosis. Therefore, realistic appreciation of the difference between "optimal" and "adequate" treatment outcomes is critical.

Following science and having a comprehensive knowledge of well-established protocols are essential to prevent complications. Following these objectives will lead to treating our patients in the most predictable manner with predictable long-term prognoses. After all, the patient is paramount.

Enjoy the content of this textbook; I am confident that you will find the comprehensive and contemporary information as essential for your daily practice as I do in mine.

Acknowledgments

This textbook was made possible by collaboration between global leaders of implant dentistry, and this collaboration has been a privilege and the highlight of my career. Without their unselfish sharing of their years of experience and knowledge, this project would not have been possible. I am extremely thankful for Drs Larry Brecht and Armand Bedrossian, who have been invaluable as coeditors as well as contributors to various chapters in this book.

Dr Danny Buser, an icon in the field of dental implants and ITI, has graciously written the foreword for this textbook, further confirming that the authors have provided implant teams with the most current and contemporary scientific information to treat our patients in the best possible manner.

I would also like to thank Elizabeth Murdoch Titcomb of Iolite Biomedical Communications for the creative illustrations throughout this textbook, allowing comprehensive and clear communications of many anatomical and technical concepts.

I am humbled by the collaboration of so many of the globally renowned authors of this textbook and am confident that we have honored the objectives set forth by my mentor, friend, and the father of osseointegration, Prof P-I Brånemark.

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SECTION I
THE IMMEDIACY CONCEPT

Included topics:

- Osseointegration Demystified
- Biologic Principles and the Immediacy Concept
- Implant Design for the Immediacy Concept
- Biomechanical Principles for Immediate Loading
- The Tissue-Level Implant

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Osseointegration Demystified

Peter Schupbach, PD, ScD, PhD
Roland Glauser, DMD

For decades now, dental implants have been successfully used to replace lost teeth, thereby restoring masticatory function, compromised esthetics, discomfort, and low self-confidence. Original surgical and restorative protocols focused on edentulous patients and included a strictly staged approach as the standard modus operandi. Over the decades, a myriad of developments has been introduced, including implant treatment of partial edentulism and aiming at simplification without jeopardizing predictability of dental implants. A main focus was on a reduction of the number of interventions, the invasiveness of the surgery, and the overall duration of the treatment. Moreover, changing patient demands have obviously stimulated a shortening of the entire treatment approach. Over the years, additional indications presenting with more advanced tissue conditions such as immediate implants have been included for treatments using dental implants.

Tooth-Supporting Tissues

The way our teeth are attached to the alveolar bone by the periodontal ligament (PDL) and protected by the marginal periodontium against foreign intruders is a masterpiece of tissue architecture and function. The cementum, PDL, alveolar bone, and gingiva form an evolutionary, structural, and functional unit called the *dental attachment apparatus*.[1] This unit serves several functions: it anchors the individual teeth to their bony alveoli and binds together one jaw's teeth into a dental arch. The PDL is a dense connective tissue composed of collagenous fibers and cells, blood vessels, and nerves. It is interposed in the space between the root surface of a tooth and the alveolar bone. Collagen fiber bundles called *Sharpey fibers* cross the space and are anchored in the root cementum at one end and in the alveolar bone at the other. Sharpey fibers are composed of hundreds of single collagen fibers. Every single fiber is deeply buried and anchored in the mineralized matrix of cementum and in the periosteum of the alveolar bone, respectively. On average, 28,000 collagen fiber bundles insert per 1 mm^2 area of cementum on a functioning tooth. The PDL works like a flexible suspension that allows resisting displacing forces and protects the teeth against an excessive occlusal load.

The primary functions of the gingiva around natural teeth are protection and stability; that is, to defend the interface between the teeth and the soft tissues against foreign invaders and to stabilize the position of the tooth in the alveolar bone. The structural framework that allows these tasks to be accomplished offers various spectacular details provided by evolution. Among them are how the gingiva and the underlying bone are protected by the highly specialized junctional epithelium and the way the collagen fibers of the connective tissue are attached to the tooth (Fig 1-1).

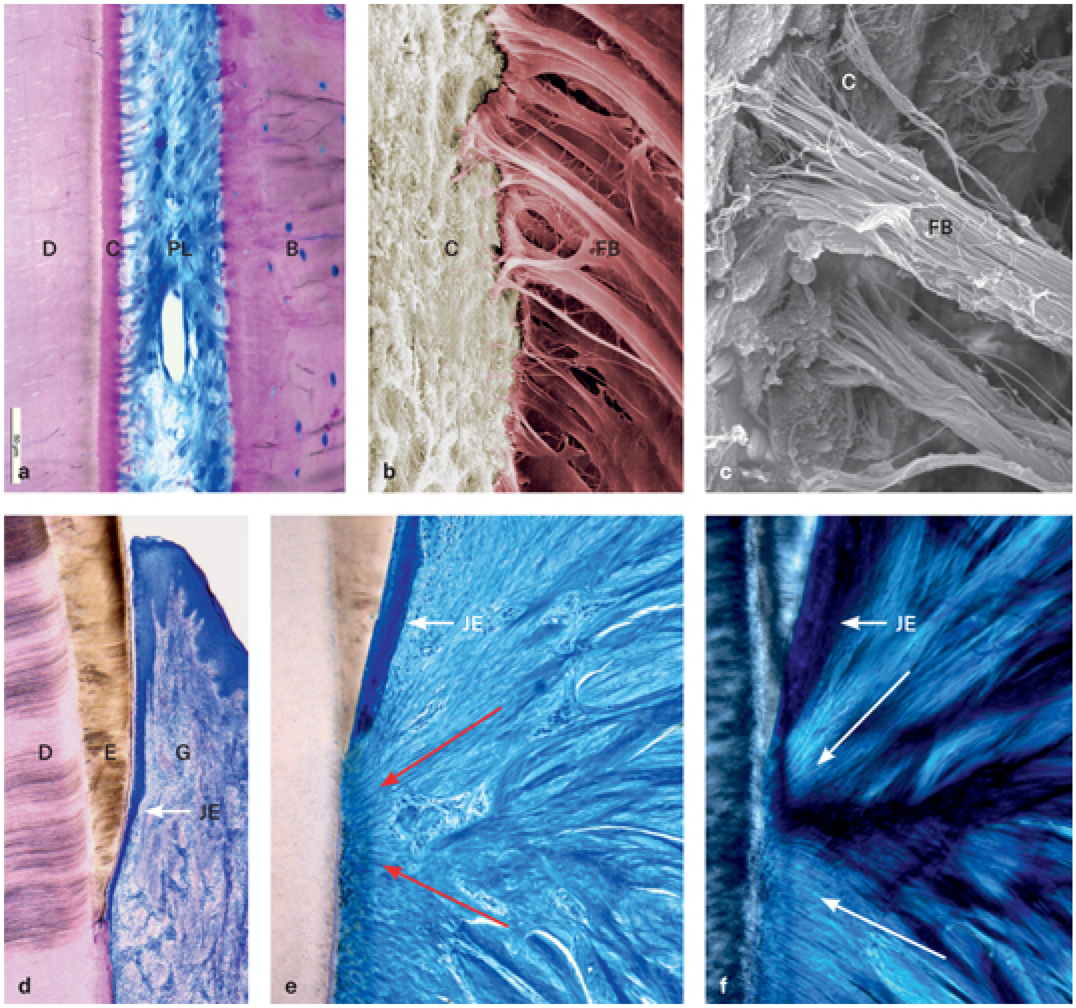

FIG 1-1 Dental attachment apparatus. *(a)* Longitudinal section through the periodontal ligament (PL). B: alveolar bone; D: dentin; C: cementum. *(b and c)* Sharpey collagen fiber bundles (FB) attached to root cementum (C). *(d)* Gingiva (G) attached to enamel (E); JE: junctional epithelium. *(e)* Functionally oriented collagen fibers *(red arrows)* viewed in transmitted light and *(f)* viewed in polarized light *(white arrows)*.

The junctional epithelium extends from the sulcular epithelium to the enamel/cementum junction and forms an epithelial, nonkeratinized sleeve around the tooth collar, thereby preserving the continuity of the epithelial coating of the oral cavity.[2] It is commonly accepted that the junctional epithelium is attached to enamel by the epithelial attachment apparatus, which comprises hemidesmosomes attached to the internal basal lamina. The unique structure and antibacterial peripheral defense mechanisms also allow for control of the lifelong constant microbiologic challenge. While the junctional epithelium forms the coronal part of the dentogingival junction, the apical portion is characterized by dentogingival collagenous fiber bundles extending in oblique angles into the root cementum. The resulting robust tissue attachment thereby supports the junctional epithelium and its rather fragile attachment mechanism by hemidesmosomes.

Wound Healing Cascade and Bone Healing Mechanism

Both general wound healing and peri-implant wound healing of both soft and hard tissues are well-understood mechanisms.[3–5] Several reviews have been published that focus on dental peri-implant healing.[6–8] Placement of an implant into the alveolar bone is followed by a sequence of healing phases and bone formation, resulting in osseointegration. A temporal sequence of peri-implant wound healing is given in Fig 1-2. This sequence is based on a dog study, and the reader must consider that the healing in this model is five times faster than in humans.

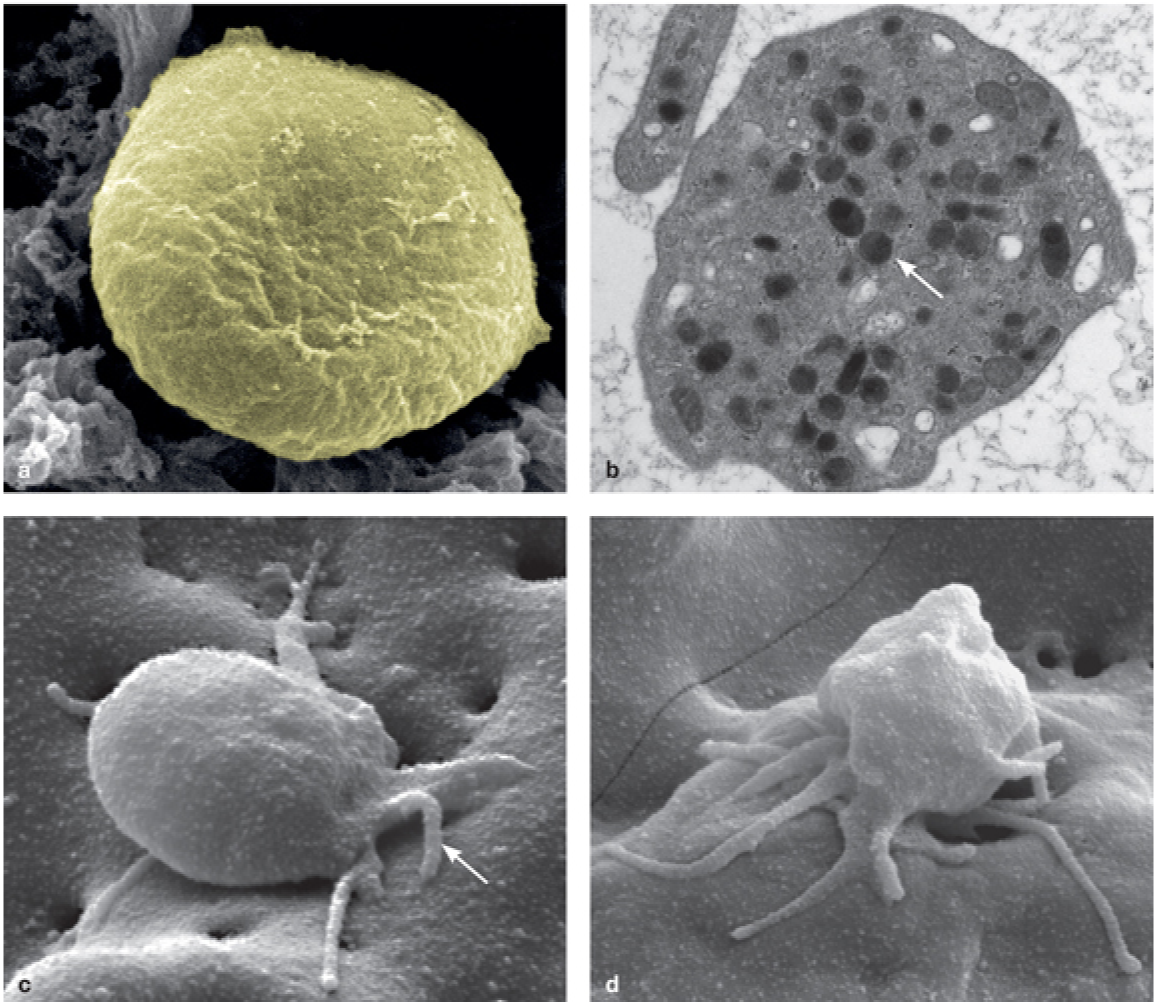

FIG 1-2 Platelet activation. *(a)* Scanning electron micrograph (SEM) of an inactive platelet. *(b)* SEM view of a section through an inactive platelet. Note the presence of numerous granules *(arrow)* containing growth factors and enzymes. *(c)* SEM of an initial stage of platelet activation. Note the outgrowth of pseudopodia *(arrow)*. *(d)* Activated platelet.

Hemostasis represents the first phase of peri-implant healing around implants. Hemostasis is begun by blood platelets, which are the first cells that interact with the implant surface. Inactive platelets have a discoid shape and are the smallest of the many types of cells in circulating blood, averaging only 2.0 to 5.0 µm in diameter and 0.5 µm in thickness. Sections in the equatorial plane reveal that platelets contain granules filled with growth factors and enzymes, such as platelet-derived growth factor (PDGF) and transforming growth factor β (TGF-β), together with vasoactive factors such as serotonin and histamine. These factors play a crucial role in regulating the following wound-healing cascade.[9] After leaving an injured blood vessel, the platelets are activated immediately by injured collagen fibers and tissues. Besides the latter, biomaterials placed in the body can activate platelets. It takes only 2 minutes to initiate the fibrin formation on titanium surfaces.[10]

When activated, platelets change in shape to become more spherical, and pseudopods form on their surface (Fig 1-3). As a result, they assume a stellate shape with a considerably enlarged surface. Chemical reactions change the surface of the platelet to make it sticky. The platelets clump together to form aggregates. Such aggregates will plug small blood vessels in the periphery of the wound, and bleeding will be slowed and finally stopped. Clotting proteins form out of fibrinogen, long sticky strands called *fibrin*. Only 10 to 20 minutes after implant placement, a blood clot composed of blood cells, activated platelets, and fibrin strands is adherent to the implant surface. Simultaneously, the platelet envelope collapses, and the granules are released. These factors will regulate early wound healing by attracting the cells needed during the next phase of wound healing, the inflammatory phase.

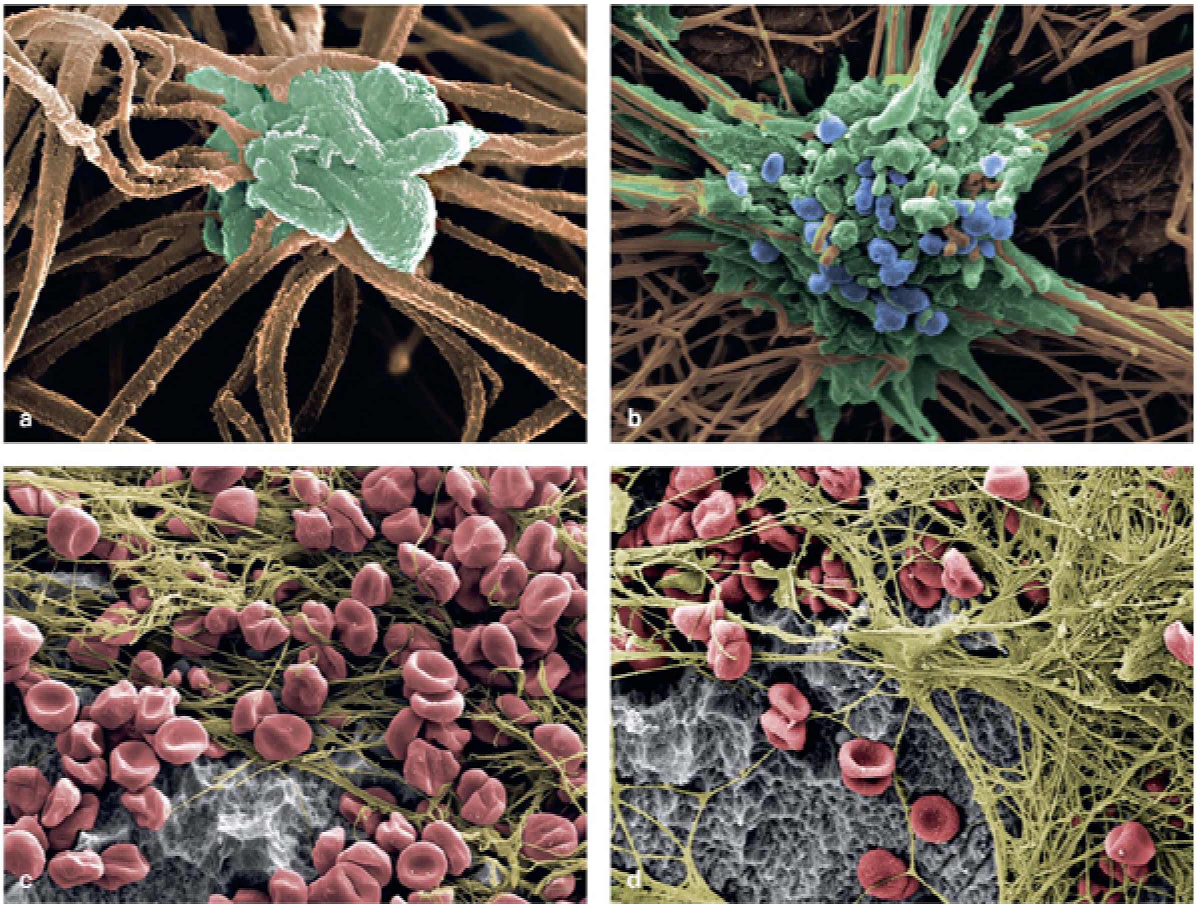

FIG 1-3 Hemostasis. *(a)* Colored SEM of a platelet *(green)* entrapped in the fibrin mesh *(brown)*. *(b)* Colored SEM showing the release of granules. *(c and d)* SEM of the blood coagulum attached to an SLActive implant surface.

Once bleeding is controlled, inflammatory cells are attracted and migrate to the wound area to promote the inflammatory phase (Fig 1-4). Initially, leukocytes are the most numerous cells, peaking at 48 hours following implant placement. The critical function of the leukocytes is the degradation of the fibrin clot as indicated by the *red arrows* in Fig 1-4d and clearance of invading bacteria and debris in the wound area. Macrophages rapidly follow neutrophils. Macrophages play multiple roles in wound healing. One of them is removing the leukocytes, thus paving the way for the resolution of the inflammation. They also attract stem cells and fibroblasts to the wound area and start angiogenesis. In this way, macrophages promote the transition to the now following proliferative phase.[11]

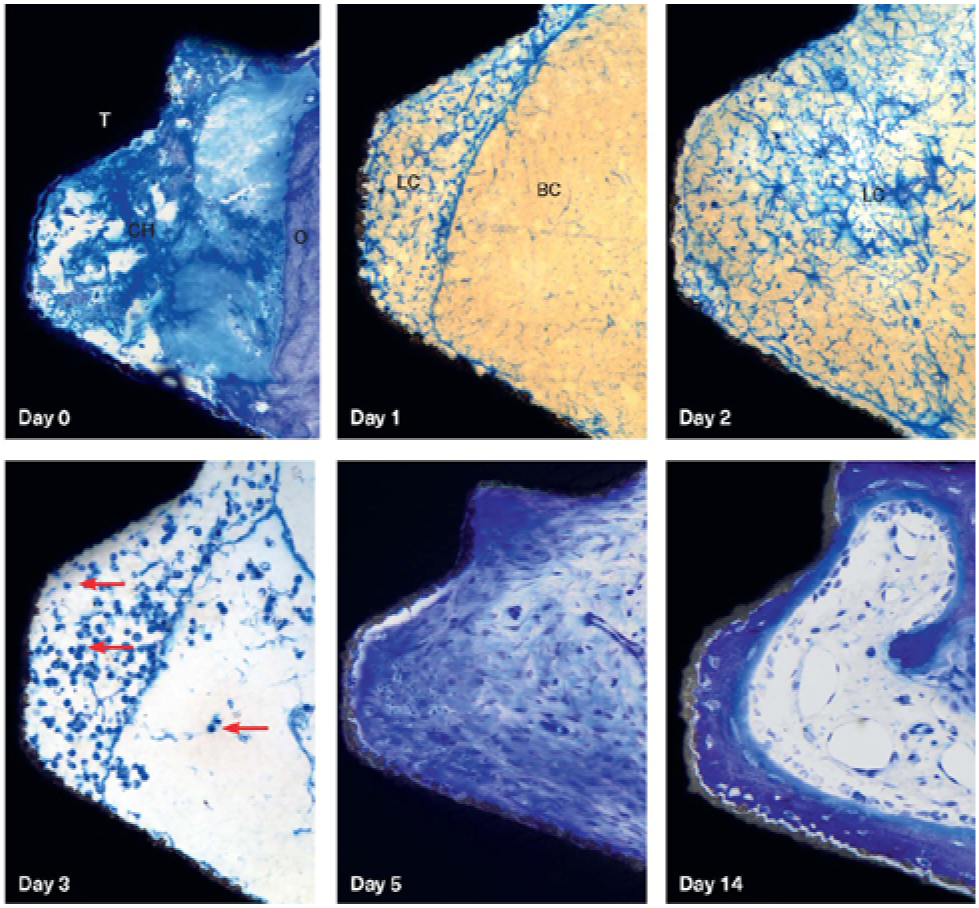

FIG 1-4 Temporal sequence of early wound healing in a dog model. Day 0: Border wall of the osteotomy (O) and bone debris between the threads (T). Day 1: A blood coagulum (BC), and partially and area of lysed coagulum (LC). Day 2: Advanced lysis of the coagulum. Day 3: Removal of the fibrin remnants removed by neutrophils *(arrows)*. Day 5: Provisional matrix between the threads. Day 14: Initial bone formation by contact osteogenesis.

The proliferative phase (see Fig 1-4) is characterized by the replacement formation of granulation tissue, angiogenesis, collagen deposition, and wound contraction by myofibroblasts. In granulation tissue formation, fibroblast-like cells invade the wound and form a provisional extracellular matrix by secreting collagen and fibronectin. New capillaries are formed by vascular endothelial cells.

They derive from endothelial cells of the original capillaries but also from the circulating endothelial progenitors.[12] Simultaneously, fibroblast-like mesenchymal cells differentiate into osteogenic cells and finally to osteoblasts. The latter will deposit a layer of collagen fibers, the so-called osteoid, which becomes mineralized, and by that, woven bone is formed. During this process, some osteoblasts will become entrapped in the osteoid layer and surrounded by the mineralized matrix and form the osteocytes in living bone.[13]

The Event of Osseointegration

The surgical preparation of an osteotomy into native or regenerated bone and subsequent implant insertion will lead to a sequence of healing steps at the tissue interface that results mostly in the event classified as osseointegration.[14] We should notice that this implant-bone relationship is a very intimate one, but obviously it is an osseoadaptation rather than a real osseointegration. Nevertheless, the terminology of osseointegration has been established and has been used consistently for more than six decades.

One of the prerequisites for proper osseointegration is a stable implant anchorage and no relative movement (also described as *micromotion* or *micromovement*) to surrounding tissue (Fig 1-5). It is mandatory to understand the importance of implant stability over time and the sequence of bone healing, and likewise important to know that implant surfaces, implant designs, and surgical approaches influence the interactions between tissues, cells, and the dental implant.

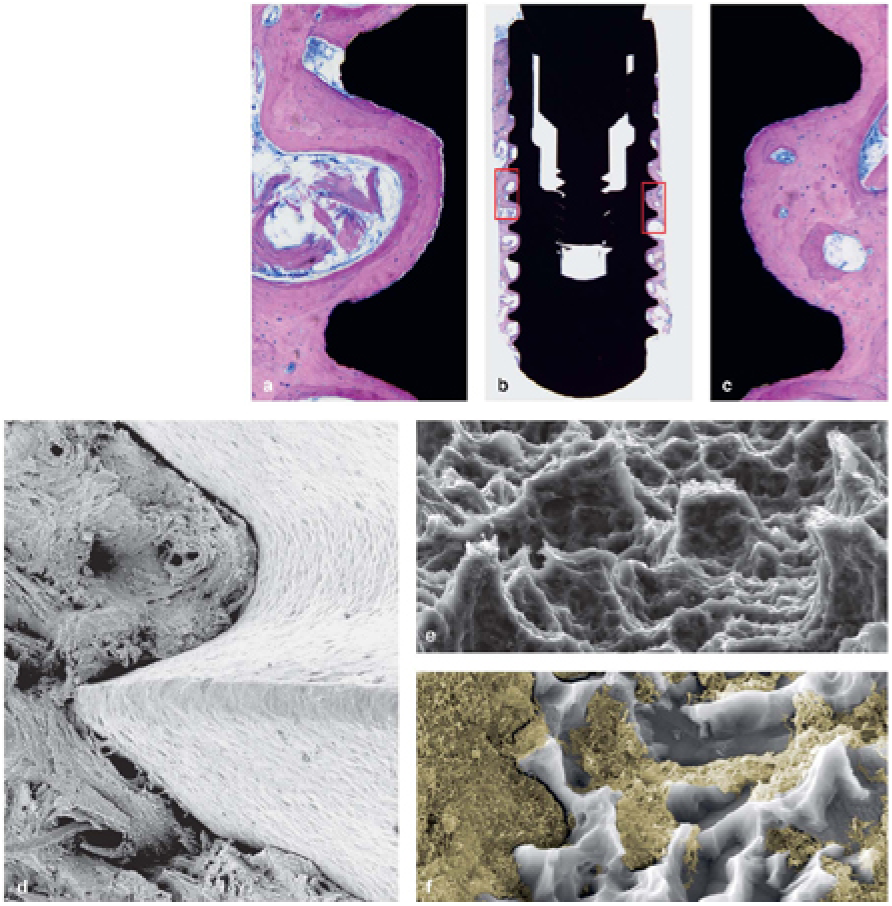

FIG 1-5 Final osseointegration. *(a to c)* Human histology of a Straumann Bone Level implant trephined out following 3 years in place. *(d)* SEM illustrating the intimate adaption of bone to an implant surface. *(e)* SEM view of an SLActive surface. *(f)* SEM view of bone anchorage in an SLActive surface.

Osseointegration refers to a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant.[15] Therefore, an implant is considered as osseointegrated when there is no relative movement between the implant and the anchoring bone.

A direct bone-to-implant contact as observed histologically may be indicative of the lack of a local or systemic biologic response to that surface. It could be concluded that osseointegration is not the result of an advantageous biologic tissue response but rather the lack of a negative tissue response.[16] Hence, with a successful