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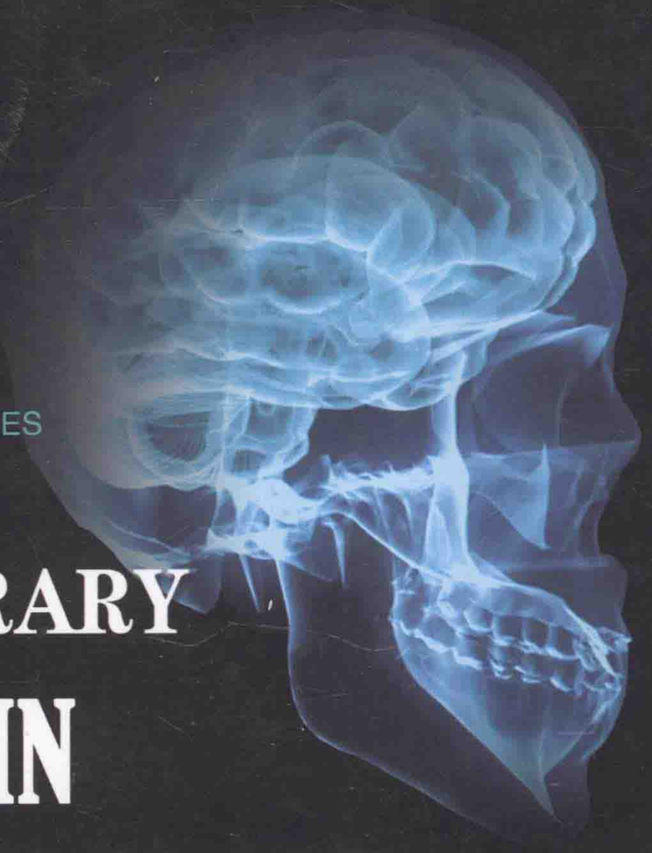

CONTEMPORARY ADVANCES IN IMPLANT DENTISTRY

· EDITOR HONGCHANG LAI ·

SCIENCE PRESS

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PREFACE

Implant dentistry has developed rapidly since the 1960s when Professor P-I Bränemark discovered the direct structural and functional connection between living bone and the surfaces of a load-bearing artificial implant, and nominated the whole process as osseointegration.

This groundbreaking discovery of osseointegration revolutionized the realm of implant dentistry and brought it from being a shunned field into one that became recognized and incorporated into dental school curricula and training programs.

Nowadays, osseointegration and implant dentistry research are at an unprecedented peak. The concepts and strategies in implant dentistry are refreshing every day due to the revolutionary development of medical technology and materials with the support of scientific clinical researches and laboratory studies.

The consequence of the boost in implant dentistry is that the field today is saturated with new implant manufacturers, novel implant designs, bone graft materials, modified implant surfaces and new surgical strategies.

The new concepts and techniques as modified hydrophilic surface, platform switching, tissue engineering, immediate placement, immediate loading, and image-based guides have boomed in the past decade. Thanks to these new innovations, the trend of shortened osseointegration healing time, minimized surgical trauma, and the enlarged indication of the dental implant placement have become the mainstream in this field.

The improvements in implant technology and its practical applications in the clinical are not a sudden breakthrough originated from one specific implant surface, a single treatment procedure, or some particular loading protocol. Rather it can be understood by conceptualizing the individual elements involved in the placing of one or more endosseous implants to support an intraoral prosthesis. It is the refinement of each of these single elements that has contributed to the understanding of osseointegration itself, and improved the technology to solve the patients' problems even further.

However, it is impossible to let the students understand and assimilate all these dazzling concepts without systematic studying. Thus it is vital to tell them where we have come from, where we are, and where we are heading.

What have we achieved in the past decade, and what are emerging as new and innovative developments in the fields of implant dentistry? By learning from our past mistakes we made and knowledge we accumulated, we may be much prepared to meet the future. Hence, this textbook attempts to answer these questions by reflecting on the latest research advances and significant evolutions of current and future applications in implant dentistry.

I hope this book can be an ideal reference for both clinicians and dental students who are interesting in dental implantology.

Last but not the least; I would like to give a sincere thank-you to all the authors and contributors of the book who provided great efforts.

Hongchang Lai

24th May, 2014

INTRODUCTION

In the past 40 years, both clinicians and researches have witnessed the rapid development of implant dentistry. Advances in implant materials, loading protocols and surgical procedures, etc. have made dental implants an irreplaceable option on the menu of dental care and treatment.

As the main body of dental implants, Implant surfaces have experienced a series of alterations, from turned machined surfaces to roughened ones, in the effort of making osseointegration process faster and more secure. Thanks to the studies on the geometry and surface topography, several surface modifications have been developed and applied, including blasted, acid-etched, oxidized, plasma-sprayed and hydrophilic surfaces, as well as combinations of these procedures. Furthermore, different shapes of the implant body are also available. For example, with the concept "platform switching", it is possible to achieve better esthetic outcome in the anterior region.

The concept of healing process has shifted as well. With the development of the immediate implantation, flapless surgery and non-submerged healing progress, the trauma of the surgery can be minimized with less and simplified surgical interventions. The loading protocols have also become diversified. The protocols as immediate loading, early loading or late loading have been developed to accommodate specific situations. Meanwhile, during the past 20 years, increasing interest has arisen regarding a concept called "alveolar ridge preservation", which was defined as "any procedure undertaken at the time of or following an extraction that is designed to minimize external resorption of the ridge and maximize bone formation within the socket." Hundreds of clinical and animal studies concerning about ridge preservation technique have been published. In these studies, bone substitutes, surgical methods and the soft/hard tissue alteration were included. However, outcomes of the recent studies should be evaluated and new insights under this topic should be explored.

Tissue engineering is an interdisciplinary field that brings together the principles of the life sciences and medicine with those of engineering. In the past 20 years, innovations in the stem cell products, biomaterials and growth factors have provided a tremendous boost for tissue engineering. Bone grafting is one of the areas that have greatly benefited from the current efforts. With the application of the bone tissue engineering, the bone graft procedure would be more cost-effective with less trauma. De novo bone formations in both horizontal and vertical directions benefited tremendously from the use of the new scaffolds, stem cells and growth factors.

The sinus floor elevation (SFE) technique, including transalveolar (TSFE) and lateral (LSFE) approach, has been developed in the past 20 years. After more than twenty years' application, sinus floor elevation procedure is thought to be a predictable augmentation technique of moderate to high complexity. Researchers and clinicians made their effort to fill the blank and solve the controversy in both theory and practice. Though the necessity of grafting materials in SFE procedure, especially in TSFE is still controversial, both LSFE and TSFE are widely applied for the patients with insufficient bone volume in the posterior maxillary region.

Due to the evolution of the CAD/CAM, CBCT scan, 3-D image reconstruction and rapid prototyping technology, image-based implant therapy is being widely used over the world. Unlike the old model-based implant surgical guides, image-based implant guides can provide highly accurate images of the relevant anatomical regions, and interactive pre-surgical visual planning can be performed in order to detect the best insertion site. With this new guide, implant surgery has become more accurate and accessible, causing less trauma and fewer complications. Furthermore, the method based on optical tracking real-time dynamic navigation technology, known as dynamic navigation have already being used in oral-maxiofacial surgeries in order to achieve real-time information of the patients.

In a word, future implant solutions will require less healing time for osseointegration process, cause fewer mechanical and biological complications, induce less trauma, while providing higher successful rate, more precision, better esthetic outcome and easier access for practitioners.

However, there still are lots of problems that need to be resolved. So far, the identification of the relative contraindication of the dental implant surgery is still a hot spot for researchers. Whether or not patients with severe periodontal disease, diabetes, and osteoporosis are suitable for dental implant insertion is also still under debate, And the consensus of the treatment strategies for these patients are yet to be studied. Furthermore, application of bisphosphonates is becoming a new problem for dentists. According to recent reports and documents, though the incidence rates of Bisphosphonate Related Osteonecrosis of the Jaw (BRONJ) and implant failure are relatively low in this group of patients, related risks should not be neglected. Further researches and clinical trials with large sample should be performed in order to clarify the pathogenesis and odds ratio of BRONJ and implant failure.

There is no doubt that the evolution of the CBCT provided us with a new radiographic diagnostic approach with less exposure dose and better view of the jaws. However, series of limitations on image-based implant therapy still exist. For example, Stereolithographic surgical guides have the limitation of lacking prosthetic landmarks. Also, accuracy of the images can be interfered by the metal crowns or bridges, which may cause radiation artifacts. The real-time navigation on dental implantation also has several unsolved problems (e.g., when the patients is just under local anesthesia, the registration would be hard to handle) which may interfere the accuracy of the surgery. However, we must admit that image-based implant guide/navigation and digital dentistry will develop promptly in the near future.

Although the timing of implant placement has been discussed for a long time, consensus on treatment strategies is far from being reached. Taking the immediate implantation in sockets as an example, the advantages of this technique are that patient may benefit by having less trauma, shortened treating period and better immediate esthetic outcome. However, the long-term esthetic complications including gingival recession, buccal bone wall resorption or perforation may affect the final outcome. Hence, the indication of the immediate implantation should be strictly implemented and further researches on the alteration of the alveolar ridge after the tooth extraction and dental implant insertion should be performed.

Meanwhile, as one of the most common post-operative complications, the peri-implantitis and peri-implantmucositis are now the focuses of researchers. Though a fair amount of papers discussing topics like animal model of the peri-implant diseases or the treatment plan have been published, the general guide of the treatment or the consensus of the treatment strategies is still under way.

In this book, we will discuss the contemporary advances and latest progresses in implant dentistry. The 11 chapters will cover the contents including surface modifications of the dental implant, the impact of general health, loading protocols, immediate placement and alveolar ridge preservation, surgical procedures of the sinus floor elevation, esthetic considerations of implant-supported restorations, preoperative/postoperative periodontal treatment, and computer-assisted implant placement. This book is an ideal reference for clinicians and dental students.

CONTENTS

CHAPTER Ⅰ

PROGRESS ON DENTAL IMPLANT SURFACE MODIFICATION

Yingxin Gu, Longfei Zhuang, Hongchang Lai

Titanium (Ti) and its alloys are extensively used as dental or orthopedic implants due to their good load-bearing properties, excellent biocompatibility and high corrosion resistance. However, clinical long-term success of dental implant is achieved not only because of implant material, but also for other properties like implant design, surgical technique, host-bone quality, load bearing, and surface quality. Surface quality, which refers to mechanical, physicochemical and topographic properties prepared by various surface technologies, is considered as an important factor in implant material. A large amount of literatures have revealed that surface properties of implants play decisive roles for molecular interactions, cellular response and bone regeneration. Over the past decades techniques for the modification of surfaces are evolving rapidly. The purpose of this chapter, therefore, is to provide an introduction to advanced surface modification processes that could be useful in dental implant manufacturing. This Chapter focuses on development in this area over the past 10 years, but earlier work has been included as well where it appeared necessary to give perspective or background for the readers.

PART Ⅰ SURFACE ROUGHNESS OF DENTAL IMPLANTS

Although the machined smooth Ti implants were once successfully used in clinical practices, there are lots of reports which demonstrate that roughened Ti implant surface can enhance the rate of osseointegration and biomechanical fixation. Especially in the cases of insufficient bone quantity or anatomical limitations, short designed implants with a rough surface have demonstrated more superior clinical outcomes than smooth surfaces. In general, the surface roughness can be classified into three levels according to the size of the features: macro-, micro-and submicro (nano)-sized topographies.

The macro scale is defined as being in the range of tens of microns to millimeters. This scale is directly related to implant geometry, with threaded screw and macroporous surface treatments giving surface roughness of more than 10 μm. Numerous reports have shown that both the early fixation and long-term mechanical stability of the prosthesis can be improved by a high roughness profile compared with smooth surfaces. The high roughness resulted in mechanical interlocking between the implant surface and bone in growth. However, a major risk with high surface roughness often indicates an increase in peri-implant infection as well as an increase in ionic leakage. A moderate roughness in a range of 1 to 2 μm has been proved to limit these two parameters efficiently.

The micro-topographic profile of dental implants is defined for surface roughness as being in the range of 1 to 10 μm. This range of roughness maximizes the interlocking between mineralized bone and the surface of the implant. A theoretical approach suggested that the ideal surface should be covered with hemispherical pits approximately 1.5 μm in depth and 4 μm in diameter. However, there is a lack of agreement in findings from *in vivo* animal experiments, where the clinical performance of micro-roughened titanium implants is described on the basis of mechanical failure tests and histological considerations. So far, it has been suggested that only a very specific surface topography with a Ra value between 1 and 2 μm provides an optimal surface for bone integration. Numerous studies have shown that surface roughness in this range resulted in greater bone-to-implant contact (BIC) and higher resistance to torque removal than that of other types of surface topography. However, the Cochrane collaboration has not found any clinical evidence demonstrating the superiority of any particular implant surface.

Surface profiles in nanometer size play a critical role in promoting proteins adsorption, osteoblastic cells adhesion and the rate of osseointegration. However, reproducible surface roughness in the nanometer range is difficult to produce with chemical treatments. In addition, the optimal surface nano topography for selective adsorption of proteins leading to the adhesion of osteoblastic cells and rapid bone apposition is unclear.

With regard to surface modifications, various techniques have been developed in order to create a rough surface and improve the osseointegration of Ti dental implants. Commonly they are divided into three general techniques: add material (e.g., titanium plasma-spraying and calcium phosphate coating), remove material (e.g., acid-etching and sandblasting), and change the material already present (e.g., anodization).

1.1 Roughening of Implants by Titanium Plasma-spraying

A titanium plasma-spraying (TPS) method has been used for producing rough implant surfaces (Fig. 1-1). This method consists in injecting Ti powders into a plasma torch at a super high temperature. The Ti particles are projected onto the surfaces of the implants where they condense and fuse together, thus forming a film about 30 μm thick. The thickness must reach 40 to 50 μm to be uniform. The resulting TPS coating has an average roughness of around 7 μm, which increases the surface area of the implant. It has been shown that this three-dimensional topography increased the tensile strength at the bone/implant interface. In a preclinical study using minipigs, the bone/implant interface formed faster with a TPS surface than with smooth surface implants presenting an average roughness of 0.2 μm. However, particles of Ti have sometimes been found in the bone tissue around the implants. The presence of metallic wear particles from endosseous implants in the liver, spleen, small aggregates of macrophages and even in the para-aortic lymph nodes has also been reported. Metal ions released from implants may be the product of dissolution, fretting and wear, and may be a source of concern due to their potentially harmful local and systemic carcinogenic effects. However, the

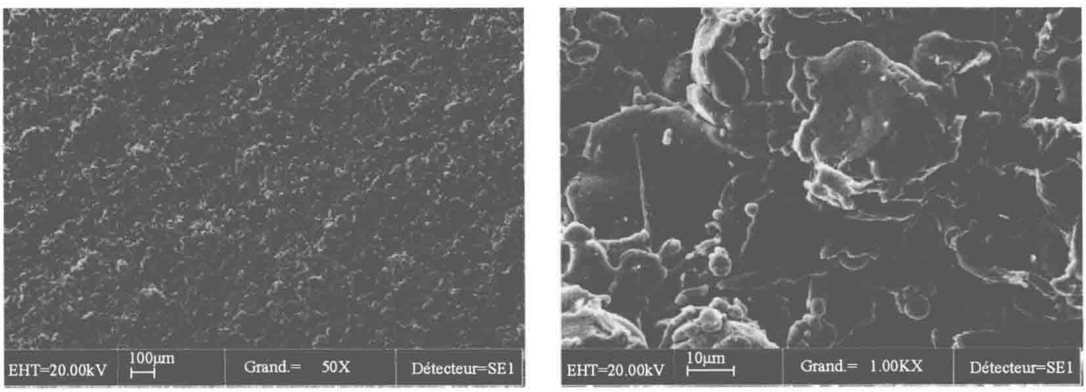

Fig. 1-1 SEM micrographs of a titanium plasma-sprayed (TPS) surface.
(Courtesy of Cam Implants BV, The Netherlands)