Biomimetic Restorative Dentistry, Volume 1

Fundamentals and Basic Clinical Procedures

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BIOMIMETIC RESTORATIVE DENTISTRY

VOLUME 1

Fundamentals and Basic Clinical Procedures

Pascal Magne, PD, Dr Med Dent

Urs Belser, DMD, Prof, Dr Med Dent

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PASCAL MAGNE

Dr Pascal Magne is an Associate Professor with tenure and the Don and Sybil Harrington Foundation Professor of Esthetic Dentistry in the Division of Restorative Sciences at the University of Southern California Herman Ostrow School of Dentistry in Los Angeles. He graduated from the University of Geneva Dental School in Switzerland in 1989 with a Med Dent degree and later obtained his doctorate in 1992 and his Privat Docent degree in 2002. Dr Magne received postgraduate training in fixed prosthodontics and occlusion, operative dentistry, and endodontics and was a lecturer at the same university beginning in 1989 until 1997. From 1997 to 1999, he was a Visiting Associate Professor at the Minnesota Dental Research Center for Biomaterials and Biomechanics at the University of Minnesota School of Dentistry. After concluding 2 years of research, Dr Magne returned to the University of Geneva Dental School and assumed the position of Senior Lecturer in the Division of Fixed Prosthodontics and Occlusion until he was recruited to the University of Southern California in February 2004. He is the recipient of multiple awards from the Swiss Science Foundation and the Swiss Foundation for Medical-Biological Grants and was honored with the 2002 Young Investigator Award from the International Association for Dental Research as well as the 2007, 2009, and 2018 Judson C. Hickey Scientific Writing Awards (for the best research/clinical report of the year published in the *Journal of Prosthetic Dentistry*). He was also the recipient of the Distinguished Lecturer Award of the Greater New York Academy of Prosthodontics in 2016. Dr Magne is the author of numerous clinical and research articles on esthetics and adhesive dentistry and is an internationally known mentor and lecturer on these topics. The first edition of this textbook has been translated into 12 languages and is considered one of the most outstanding books in the field of adhesive and esthetic dentistry. Dr Magne is a founding member of the Academy of Biomimetic Dentistry and a mentor of the Bio-Emulation think-tank group. In 2012, he launched a revolutionary approach to the teaching of dental morphology, function, and esthetics (the 2D/3D/4D approach) for freshman students at the Herman Ostrow School of Dentistry at USC.

QR codes like this are placed throughout the book and can be scanned to access exclusive video content demonstrating techniques or further explaining concepts. They will be updated as new material becomes available.

URS BELSER

Prof Urs Belser graduated from the Dental Institute at the University of Zurich in Switzerland. He received postgraduate specialty training in reconstructive dental medicine (board-certified specialist) at the University of Zurich and was an Assistant Professor and then Senior Lecturer in the Department of Fixed Prosthodontics and Dental Materials there (Prof Dr Peter Schärer, MS) from 1976 to 1980. He was also a Visiting Assistant Professor from 1980 to 1982 in the Departments of Oral Biology (Prof Dr A.G. Hannam) and Clinical Dental Sciences (Prof Dr W. A. Richter) in the Faculty of Dentistry at the University of British Columbia in Canada. Between 1983 and 2012, Prof Belser acted as the Professor and Head of the Department of Fixed Prosthodontics and Occlusion at the University of Geneva School of Dental Medicine, serving as the president of the Swiss Association of Reconstructive Dentistry from 1984 to 1988. He was the recipient of the Scientific Research Award of the Greater New York Academy of Prosthodontics in 2002, President of the European Association of Prosthodontics (EPA) from 2002 to 2003, and Visiting Professor at Harvard University in the Department of Restorative Dentistry and Biomaterials Sciences (Prof Dr H. P. Weber) in 2006. Since 2012 he has been Guest Professor in the Department of Oral Surgery (Prof Dr D. Buser) and Department of Reconstructive Dentistry (Prof Dr Urs Braegger) at the School of Dental Medicine at the University of Bern. In 2013 he became an Honorary Fellow of The International Team of Implantology (ITI). Between 2013 and 2017 he served as editor-in-chief of *Forum Implantologicum* (ITI), and in 2014 he became a lifetime honorary member of the American College of Prosthodontists (ACP) and received the Lecturer of the Year Award. In 2018 he was presented the Morton Amsterdam Interdisciplinary Teaching Award (together with Prof Dr D. Buser). Prof Belser's research is focused on implant dentistry, with special emphasis on esthetics and the latest developments in the field of CAD/CAM technology and high-performance dental ceramics, as well as on adhesive reconstructive dental medicine.

Emerging concepts in biomimetic restorative dentistry (BRD) provide the ability to restore the biomechanical, structural, and esthetic integrity of teeth with utmost respect for biologic structures (pulp and periodontal tissues). Adhesive techniques constitute the cornerstone of BRD, and novel restorative designs are striking elements of this nascent approach to tooth restoration. Indications for bonded restorations have expanded to include more advanced destructive conditions such as severely broken-down teeth, crown-fractured teeth, and nonvital teeth. As a result, considerable improvements have been made both medicobiologically and socioeconomically: More sound tissue is preserved, tooth vitality is maintained, and treatment is less expensive than traditional and more invasive prosthodontics.

BRD offers restorative solutions that balance the functional and esthetic needs of the anterior and posterior dentitions. A wide range of restorative techniques, from direct to semi-(in)direct and indirect approaches, are available to cover each patient's specific needs. Combining ceramics and composite resin optimal stiffness, their wear and surface characteristics, and the biomechanical strength achieved through high-performance bonding enable the crown of the tooth as a whole to support masticatory function. By the same token, the optical effects inherent in the tooth and the lifelike features of composite resins and ceramics make this restorative approach the ultimate in esthetic satisfaction for both the practitioner and the patient.

Watch nature...

Not manmade, not humanly inspired, but divinely designed ...


Copyright
Not for publication
Quintessence
... and faithfully emulated.

DEDICATION

To my wife, Geibi, and my children, Erine and Santiago, the most precious gifts from God in my life. To my brother, Michel, whom I love dearly and who shared and brought to light his passion for God, for dentistry, and for dental technology. To my sister, Marina, her husband, and my nephews, who were always present and available despite the physical distance separating us. To my nieces, also distant but always present in my heart. In memory of my mother, Agnès, who was taken from us by cancer too early, and my father, Albin, who supported me and encouraged me in all situations.

—PM

In memory of my mother, Heidi, and my father, Theodor. To my wife, Christine, for her unfailing support and patience. To my children, Marc and Michèle, and grandchildren.

—UB

Geneva, 2018

As iron sharpens iron, so one person sharpens another. —Proverbs 27:17

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FOREWORD

It is with considerable pleasure that I write the foreword to Dr Magne and Prof Belser's book, which takes the science of esthetic dental reconstruction to a new level both clinically and academically. Dr Magne spent 2 years as a Visiting Associate Professor in the Minnesota Dental Research Center for Biomaterials and Biomechanics at the University of Minnesota, where many of the ideas promulgated in this book were hotly debated, refined, and tested in a modeling and experimental environment. In this book, the clinician will find all that he or she could wish for in terms of indications and the classic clinical steps for tooth preparation, laboratory as well as CAD/CAM procedures, adhesive luting procedures, and maintenance protocols. Those who have heard Dr Magne lecture will not be disappointed. In fact, they will find much more that is practically and intellectually satisfying.

The central philosophy of the book is the biomimetic principle—that is, the idea that the intact tooth in its ideal hues and shades, and perhaps more importantly in its intracoronal anatomy and location in the arch, is the guide to reconstruction and the determinant of success. The approach is basically conservative and biologically sound. This is in sharp contrast to the porcelain-fused-to-metal technique, in which the metal casting with its high elastic modulus makes the underlying dentin hypofunctional. The goal of the authors' approach is to return all of the prepared dental tissues to full function by the creation of a hard tissue bond that allows functional stress to pass through the tooth, drawing the entire crown into the final esthetic result.

I hope that this new edition of the book will receive a wide readership and that its principles will be carefully studied and become fully established in teaching and research, as well as de rigueur in the practice of restorative dentistry.

William H. Douglas, BDS, MS, PhD
Former Director, Minnesota Dental Research Center for Biomaterials and Biomechanics
Former Chair, Department of Oral Science, University of Minnesota
Professor Emeritus, School of Dentistry, University of Minnesota
Minneapolis, Minnesota

Minneapolis, 1998

FOREWORD

In today's 24/7 media culture, everyone strives to become an expert, but not everyone realizes what it actually takes in order to reach the level of a master. True mastery requires enormous amounts of work, persistence, and perseverance. It requires time and discipline. It requires fortitude and effort. It requires setbacks and failures.

From 2005 to 2007 while teaching alongside Michel Magne and Dr Pascal Magne at the USC Herman Ostrow School of Dentistry, I witnessed mastery personified in their pursuit of excellence. Nothing was left to chance, from the specialized equipment utilized in order to test his null hypotheses to the research and development carried out by his talented postdoctoral students, to continually optimize protocols enabling the dental community to achieve the highest quality of work for their patients.

From the start and over the years Pascal has become a revered mentor and cherished friend, and he ever remains a distinguished colleague of mine. The authenticity in his didactic approach paired with his common-sense clinical methodologies have inspired a new generation of adhesively driven restorative dentists to further explore the science and art of dentistry in order to faithfully bioemulate nature.

A polymath in every sense, Dr Pascal Magne has the disposition of a perioral architect simultaneously operating like an intraoral engineer. To marvel, wonder, and attempt to decode the divine design of our Creator has become his passion, his vocation, his calling.

Yet the simplicity and profundity of his message is to observe and preserve the harmony of the dental structures and, only when absolutely necessary, to intervene with the utmost respect and care to the natural dental substrates, utilizing biomimetic principles and analogous restorative biomaterials in such a modality as to ultimately conserve and reinforce the remaining sound tissue structures.

First do no harm; then try to prevent it at all costs.

Panaghiotis K. Bazos, DDS, MClinDent Orthodontics, MOrth RCS (Edin.)
Founder and CEO, Bio-Emulation
Private Practice in Restorative Dentistry and Orthodontics
Aigio, Greece

Los Angeles, 2007

BRD gave rise to a new generation of multitalented dentists and dental technicians, intently enthusiastic for advancing the concept further by diving deeper into understanding the archetype of the natural tooth. The Bio-Emulation movement has become a beautiful fruit of this laborious endeavour. If there is a single word that makes creative people different from others, it is the word *simplicity*. Many minds that are interconnected by one universal mindset that allows for sharing their collective experience and tacit knowledge, by freely exchanging ideas and conceptualizations. Special appreciation and gratitude for my fellow Bio-Emulator, esteemed colleague and dear friend, Dr Javier Tapia-Guadix (Madrid, Spain), one of the most inspirational and instrumental members of the group. His amazing creativity and undeniable talent in CGI and mesmerizing animations are on full display in chapters 1 and 2.

PREFACE

The most exciting developments in dentistry have emerged within the past decade. Digitally guided implant dentistry, guided tissue regeneration, adhesive restorative dentistry, and CAD/CAM restorations are strategic growth areas both in research and in clinical practice. However, the many advances in dental materials and technology have generated a plethora of dental products in the marketplace. Clinicians and dental technicians are faced with difficult choices as the number of treatment modalities and technologic tools continues to grow. Further, changes in technology do not always simplify technique or decrease treatment costs. Prudence and wisdom need to be combined with knowledge and progress when it comes to improving our patients' welfare. In this perplexing context, no one will contest the need for less expensive, satisfactory, and rational substitutes for current treatments. The answer emerged from an interdisciplinary biomaterial science called *biomimetics*.[1] This concept of medical research involves the investigation of the structure and physical function of biologic "composites" and the design of new and improved substitutes. Biomimetics in dental medicine has increasing relevance. The primary meaning for dentistry refers to processing material in a manner similar to that by the oral cavity, such as the calcification of a soft tissue precursor. The secondary meaning refers to the mimicking or recovery of the biomechanics of the original tooth by the restoration. This, of course, is the goal of restorative dentistry.

Several research disciplines in dental medicine have evolved with the purpose to mimic oral structures. However, this nascent principle is applied mostly at a molecular level, with the aim to enhance wound healing, repair, and regeneration of soft and hard tissues.[2,3] When extended to a macrostructural level, biomimetics can trigger innovative applications in restorative dentistry. Restoring or mimicking the biomechanical, structural, and esthetic integrity of teeth is the driving force of this process. Therefore, the objective of this book is to propose new criteria for esthetic restorative dentistry based on biomimetics.

Biomimetics in restorative dentistry starts with an understanding of hard tissue structure and related stress distribution within the intact tooth, which is the focus of the opening chapter of this book. It is immediately followed by a systematic review of parameters related to natural oral esthetics. Because the driving forces of restorative dentistry are maintenance of tooth vitality and maximum conservation of intact hard tissues, the next chapters describe the ultraconservative treatment options and armamentarium that can precede a more sophisticated treatment. The description of semi-(in)direct approaches concludes Volume 1 of the book; those techniques can be considered when direct techniques are challenging to apply (eg, large restorative volume with cervical margins in dentin) and when indirect technique costs are not justified or simply not affordable by the patient.

The core of Volume 2 of the book centers on the application of the biomimetic principle in the form of anterior indirect bonded porcelain restorations using composite resins and ceramics. The broad spectrum of indications of anterior indirect bonded porcelain restorations is described, preceded by detailed instruction on the treatment planning and diagnostic approach, which is the first step for every case. Proposed treatments are described step by step throughout both book volumes, including tooth preparation and impression, laboratory and CAD/CAM procedures related to the fabrication of composite resin and ceramic workpieces, and their final insertion through adhesive luting procedures. CAD/CAM techniques are also included as pertinent tools for the achievement of the biomimetic principle. Volume 2 ends with discussion of the follow-up, maintenance, and repair of bonded restorations.

Acknowledgments

We should always remember that a key element for successful and predictable restoration is teamwork, and an essential ingredient for teamwork is humility—to consider others better than oneself. We must try to serve each other rather than expect to be served. I would have been unable to achieve this work without the valued collaboration of other dentists, dental technicians, specialists, and researchers, all mentioned below.

In 2003, Dr Harold Slavkin, as a Dean, along with Dr Cherilyn Sheets, had a vision that included recruiting me to the University of Southern California (USC), thus initiating our amazing journey to the United States in 2004. The numerous visiting scholars in my research laboratory as well as all graduate dental students have been enlightening my daily academic activities. They have been a constant source of fresh air and the breath of my life at USC. Our research works have been possible thanks to the unconditional gifts of various colleagues, in particular Dr Parto Ghadimi. I also want to thank all the companies who provided their materials for research with no strings attached.

There are numerous ceramists and laboratories who have inspired me much and offered support in one way or another. Special thanks to Willi Geller, Klaus Müterthies, Claude Sieber, Enrico Steiger, Naoki Hayashi, Sascha Hein, August Bruguera, Giuseppe Romeo, Milos Miladinov, and Sam Alawie, among others.

Witnessing the birth of The Academy of Biomimetic Dentistry with Dr David Alleman as well as The Bio-Emulation group with Dr Panaghiotis Bazos, Javier Tapia Guadix, and Gianfranco Politano have been among the most memorable

moments of my journey. Their members have been instrumental in stimulating my mind and pushing the boundaries of my creativity.

I feel so blessed to have studied under Prof Urs Belser; his teaching and guidance have been invaluable to me and his support always unconditional. Life lessons have been learned thanks to him. He is my first mentor.

I extend my endless appreciation to my brother, Michel Magne, MDT, my second mentor, for his significant contributions to the chapter on laboratory procedures and for his skills in fabricating the ceramic restorations for most of the cases in this book. Our brotherly "BOND" is to be compared to a perfect resin-ceramic bond that has overcome the numerous storms of life. Our synergy is also that of a perfectly bonded porcelain restoration: "Michel, delicate and fragile like porcelain but strong once bonded. Pascal, more resilient like composite resin but made beautiful by Michel's skills."

Special thanks go to Dr William Douglas, my third mentor, but also Drs Ralph DeLong, Maria Pintado, Antheunis Versluis, and Thomas Korioth at the University of Minnesota for their help and friendship during my 2-year research scholarship there that led to my PhD. They expanded my vision and knowledge of scientific research in biomaterials and biomechanics.

I also acknowledge my precious patients, who directly contributed to the making of this book, and the private practitioners who donated extracted teeth for the studies and illustrations.

Special thanks to Mr William Hartman and the Quintessence Chicago team—Leah Huffman, Sue Zubek, and Sue Robinson—for pushing the envelope of my creativity and rendering this work in the most exquisite way. A particular thought goes to the late Mr Peter Sielaff from Quintessence Berlin who had been instrumental to the making of the first edition of the work.

Finally, I give honor and glory to my Lord and Savior, Jesus Christ, my mentor above all mentors, who has made all of my projects possible through his gracious love. He also provided my soul mate, Geibi, and two additional gifts, our children Erine and Santiago. None of this work would have been possible without them.

I hope that you will enjoy reading this work and applying its content for the good of your patients and the joy of practicing biomimetic restorative dentistry.

God bless you!

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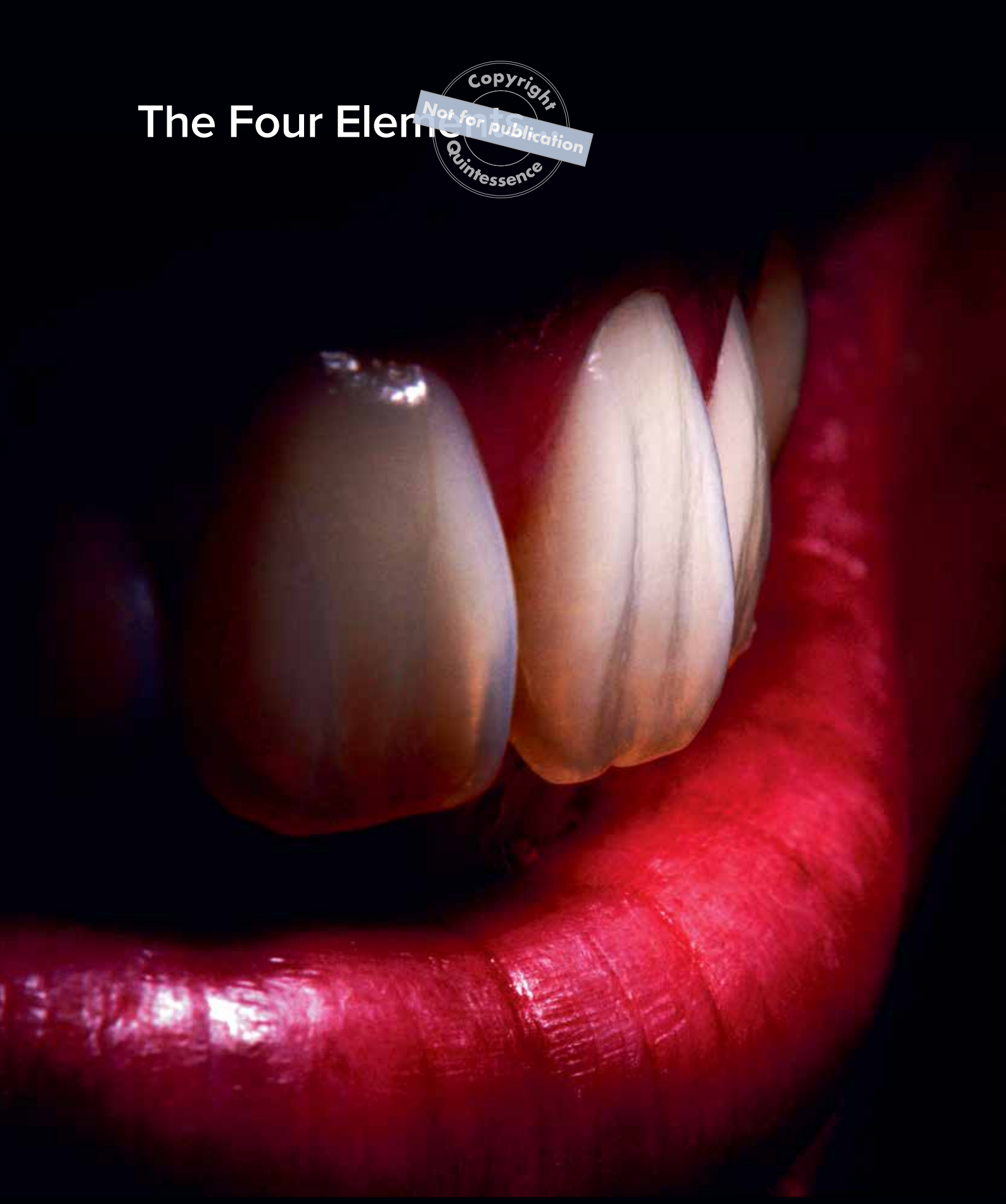
Pascal Magne

The Four Elements



1. SCIENCE. *Science comes from the work of men.*

Hence, science can be flawed. Humans make mistakes, and during the many steps in the making of a scientific work, imperfections can be cumulated. Scientific interpretation adds to the widening of the prediction values. While science is undeniably necessary to the growth of knowledge, it may become much less valuable if not paired with common sense.

2. EXPERIENCE. *Experience is YOUR story.*

It is made of the practical knowledge, skill, or elements that you accumulated from direct observation or participation in events or in a particular activity. Experience may be considered as part of science but is not accepted per se as scientific, which is a contradiction because experience is truly priceless.

3. COMMON SENSE. *Common sense is placed by God in your heart.*

Common sense is the ability to make a good decision. It is based on wisdom (knowing what to do) and discretion (knowing when and where to do it). Common sense triggers further investigation of scientific facts that do not add up. Common sense allows you to look at situations the way God does.

Proverbs 3:21–22
Dear friend, guard clear thinking and common sense with your life;
don't for a minute lose sight of them. They'll keep your soul alive
and well, they'll keep you fit and attractive.

4. THE PATIENT!

Science, common sense, and experience may lead to a specific therapeutic approach. The patient, however, through informed consent, must be the major decision maker. Timing, affordability, culture, and history might preclude the chosen therapy and call for a different approach. The patient's constraints and preferences must always be respected.

Albert Einstein confides, "I want to know God's thoughts ... the rest are details."

Science, experience, common sense, and the patient

It is undeniably true that we live in very intense times in the history of humanity. The times to come do not promise to be easy, so it is more important than ever to remain in the faith. A faith that will prove that this fragile mosaic that we form (each of us as a piece of broken glass) has the power to transform itself into an eternal work of art. In this context, which challenges our beliefs, we also try to be high-level professionals. And it must be admitted: In dentistry the plethora of materials and techniques at our disposal is not without challenges for our "dental faith." As a practitioner trying to find one's way through an avalanche of new dental products, new technologies, conflicting scientific publications, etc, it is more important than ever to examine one's beliefs, values, and the foundations that will enable one to make the most appropriate choices. There are four synergistic components involved in the decision for the optimal treatment plan:

1. Science: The scientific method is a priori a fundamental basis according to which a hypothesis is tested with various levels of evidence (expert opinion, in vitro test, clinical case presentations, case series, cohort and randomized controlled trials, systematic reviews, and meta-analyses). The scientific approach is unfortunately not without flaws. The conditions of study do not always represent the daily clinical reality. Due to medical ethics, it is not possible to standardize all clinical conditions. A multitude of confounding variables, such as the operator, the nature of the clinical situation, the habits of the patient, etc, "adulterate" the results. Therefore, it is not uncommon for the null hypothesis to be confirmed (no difference between the method or material tested and the control method), particularly with clinical studies, which by default have a majority of confounding variables. As such, the combined studies of numerical simulation and in vitro tests represent considerably advantageous research tools because of the extreme possibilities of standardization.[1,2] Unfortunately, however, the latter are not part of the official hierarchy of evidence-based medicine.

2. Experience: It has been shown that one of the significant variables of clinical practice is represented by the clinician themself and their ability to master a particular approach. In medicine, for example, a study of carotid stenting has clearly shown that patients of experienced operators have less risk of complications.[3] Similar data exist with respect to dental bonding performance both in vitro and in vivo.[4,5] Clinicians who participate in many training courses and develop these skills will therefore tend to produce more reliable results.[6]

3. Common sense: It is established that many acts of daily practice lack high-level scientific evidence. The scientific community itself recognizes the existence of a "talking pig."[7] It is a parable explaining that common sense must be recognized even in the scientific method. According to this parable, a researcher trained a pig to speak. "Is it madness?" you say to yourself. But we bring this pig to speak in front of you and the pig says, "Good evening," and proceeds to a summary of the news of the day for you. We hope you would be surprised by this phenomenon and would not be necessarily interested in a random selection of 100 pigs to verify this. The fact that any pig can talk is what is important. By the same principle, it is possible to ask whether a randomized study is necessary to prove that the use of a parachute can prevent death in the event of

an airplane disaster.[8] These examples of "taking pigs" demonstrate that common sense must be used in every situation. It is not uncommon for conflicting scientific data to be produced, which then requires a decision based on experience and common sense.

4. The patient: Finally, it is quite possible that science, experience, and common sense all point to the same therapeutic solution. However, the patient may find it impossible to choose this solution, for example for economic reasons or availability. A segmentation of the treatment or a "low cost" alternative must then be explored, which does not necessarily correspond to the ideal solution proposed by the health care team. Each patient presented in this book has been treated with the FOUR elements in mind.

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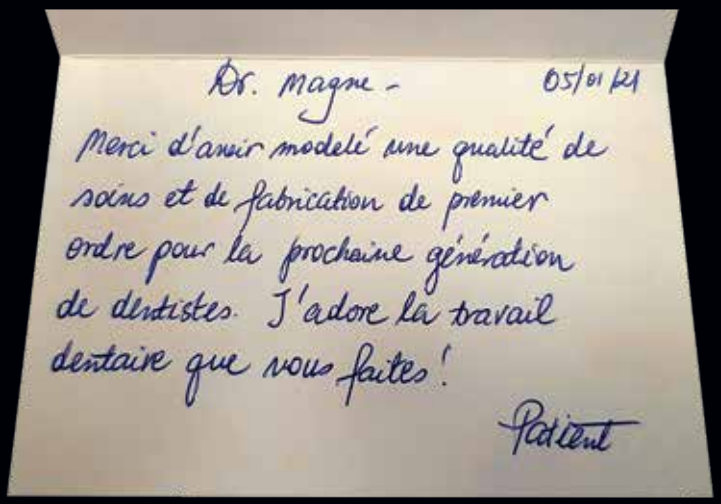
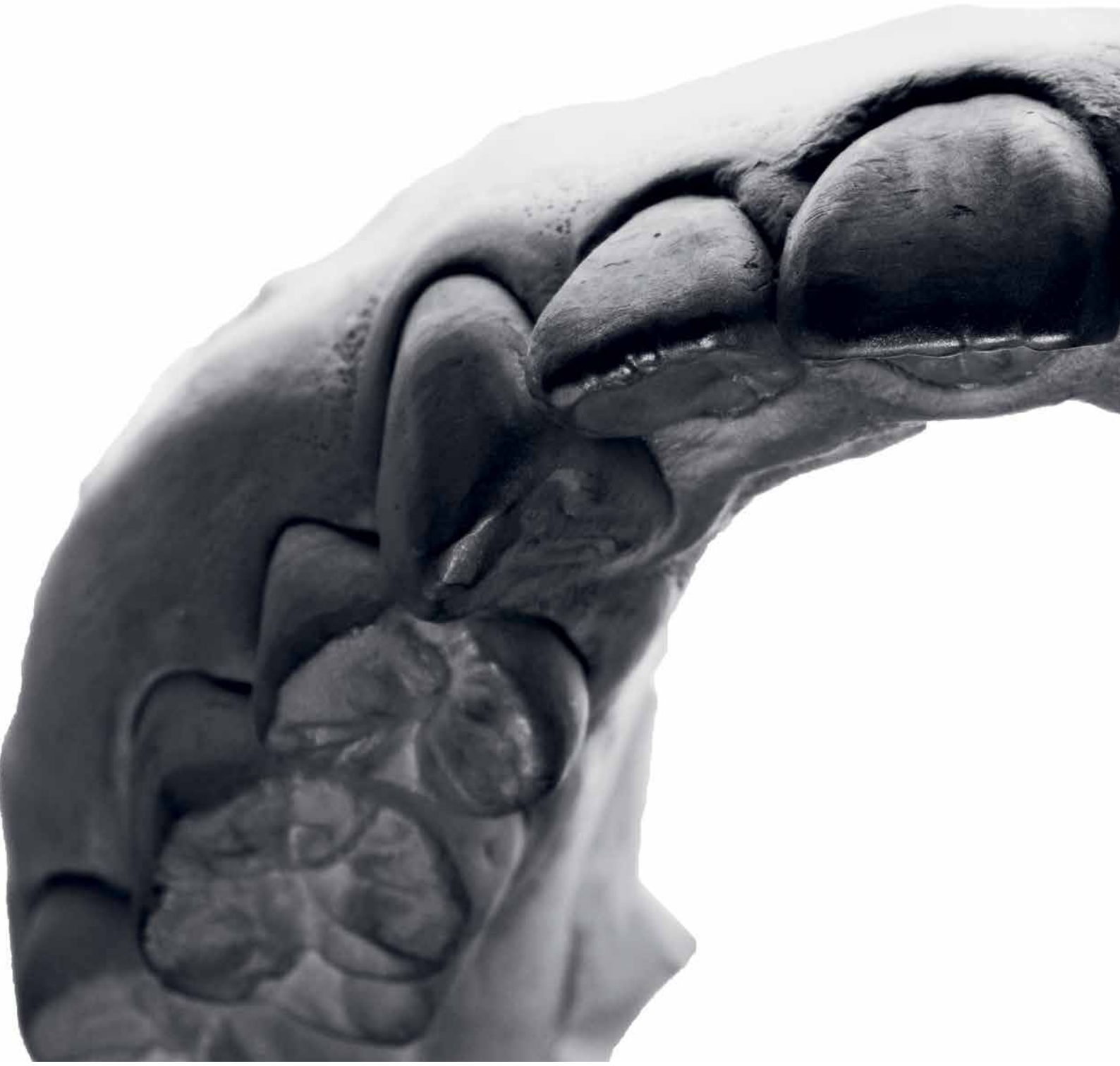
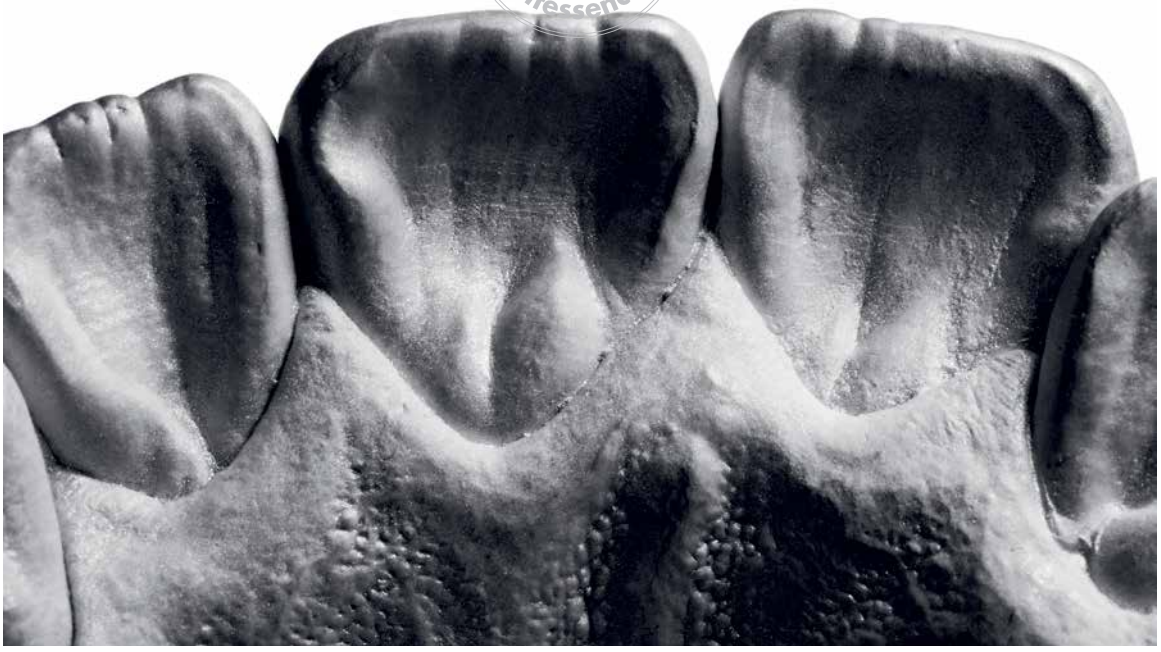
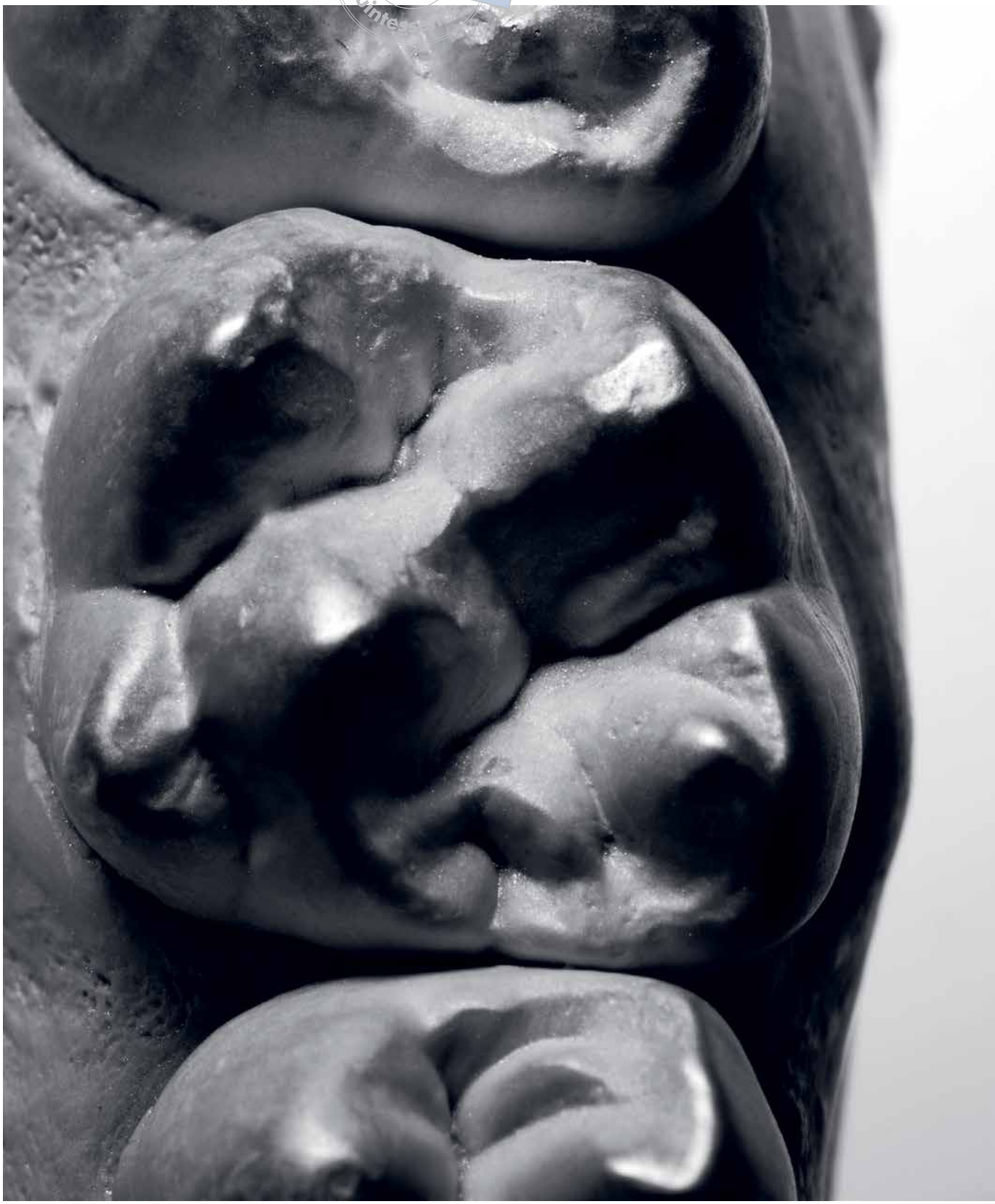


Dr. Magne, thank you for providing top-notch quality of care and workmanship for the next generation of dentists. I love the work you do.
Patient

GALLERY







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