The subject of Computerized Occlusal Analysis has evolved over a 30-year span beginning in 1984 to where many clinical and research applications that utilize the T-Scan technology have been developed in many of Dental Medicine’s disciplines. The clinical implementation of the T-Scan with dental patients is a major diagnostic and treatment advance over the traditional, non-digital occlusal indicator methods that dentists have employed over the past 100 years. Computerized Occlusal Analysis has brought occlusal force and timing measurement to a significant portion of daily dental practice that, until the inception of the T-Scan, had always been subjectively interpreted by the clinician. Because of the T-Scan’s relative occlusal force and timing measurement capabilities, applying its data has been shown in studies to definitively improve occlusal design end-result precision. As such, the field of Computerized Occlusal Analysis has grown to not only include the science and practice of Dental Occlusion but also encompasses Fixed and Removable Prosthodontics, Implant-Supported Prosthodontics, Periodontics, Orthodontics, Aesthetic Dentistry, Tooth Sensitivity, Temporomandibular Disorders and Mandibular Orthosis, and Body Posture and Balance.

Today, Computerized Occlusal Analysis technology offer solutions to the many commonly observed and frequently encountered occlusal problems that practicing dental clinicians regularly attempt to manage (and often struggle with), without the aid of digital occlusal measurement. Despite the clear superiority of the T-Scan method over traditional occlusal indicators, presently, the T-Scan technology still faces significant challenges in gaining academic acceptance and widespread clinical use with dental patients. Notwithstanding that the T-Scan method has proven itself in published studies to be reliable, reproducible, and accurate, the T-Scan technology has been somewhat overlooked by Dental Medicine in favor of the routinely used traditional, non-digital occlusal indicators that are incapable of actually measuring occlusal force and timing. In this era of Evidenced-Based Dental Medicine, it is surprising that articulated stone casts, occlusal wax, silicone imprints, and articulating paper strips and foils are still widely believed to be capable of reporting occlusal force levels by their appearance characteristics. These non-scientifically based beliefs have limited the perceived need for the T-Scan technology in clinical dental practice, despite the fact that none of the traditional occlusal indicators have been proven scientifically capable of measuring occlusal force levels, reproducing the reporting of consistent occlusal force levels trial to trial, or measuring and reporting on occlusal contact timing sequences.

This Handbook of Research of Computerized Occlusal Analysis Applications in Dental Medicine is a comprehensive compilation designed to illustrate to modern Dental Medicine the scope and breadth of the field of Computerized Occlusal Analysis. Its intended audience is dental healthcare providers that practice within the many disciplines of Dental Medicine, Dental Medicine educators and researchers, dental school Occlusion program directors, present-day undergraduate dental students, postdoctoral
program directors, and graduate students in Prosthodontics, Implant-Supported Prosthodontics, Periodontics, Orthodontics, and Temporomandibular Disorders. It should also be read by dental hygienists and chairside assistants, as these axillaries are often called upon by their employer-dentist to use the technology with new patients, as one component of a comprehensive patient examination.

Most notably, the authors have targeted this book at the dentist clinician, as it is the clinician who is regularly called upon to treat occlusal problems in daily dental practice. By reading this compilation, a practicing clinician will be greatly aided in their daily practice of Occlusion by applying the T-Scan use principles and measured occlusal concepts described herein. Specific efforts have been made to provide a scientific foundation for the included T-Scan-based treatment procedures illustrated, so that clinicians who utilize this book as a *Clinical Guide* will be learning to treat occlusal problems with an evidence-based approach rather than with a subjective one.

Although the book is not specifically directed at researchers in the field of Dental Occlusion, the relative occlusal force and time-sequence measurement capabilities of the T-Scan technology make it ideal for documenting occlusal function in a study environment. Researchers are encouraged to read this book to gain proper T-Scan use skill knowledge prior to designing their own T-Scan occlusal function studies, or when replicating existing, previously published T-Scan studies. In this way, future T-Scan researchers will better understand how to properly employ T-Scan data sets, which will make any results reported from future T-Scan-based research studies far more reliable than if the same researchers were to employ poor T-Scan technique from a lack of adequate T-Scan use knowledge.

**ORGANIZATION OF THE BOOK**

This book has been divided into 6 sections:

Section 1, “Evolution of the T-Scan Technology,” introduces the history of the T-Scan system from its initial inception in 1984 through until the present day. Chapter 1 details the four T-Scan system versions and describes the scientific studies that inspired important system accuracy and repeatability improvements that were incorporated into each version’s development.

Chapter 2 compares the various commercially available, commonly employed, traditional non-digital occlusal indicators to the T-Scan technology for their relative occlusal force measurement capability, the ability to detect occlusal force excess, and whether they possess time-sequence measurement and reporting capability. Additionally, a section of this chapter is devoted to whether the clinician’s Subjective Interpretation involved in using non-digital, traditional occlusal indicators makes them potentially maximally invasive when compared to the T-Scan, whose measurement capability eliminates the clinician’s Subjective Interpretation, *making it a minimally invasive treatment technology*.

The emphasis of Chapter 3 is to demonstrate the accuracy and reliability of the T-Scan occlusal measurement method, assess the reproducibility of the recording sensor and the system’s force output reporting consistency, while also addressing the time-dependant nature of the occlusal force build-up that occurs during patient self-intercuspation. This chapter specifically addresses the repeatability of the T-Scan recording method, determining that the T-Scan method is reliable and accurate.

Section 2, “The T-Scan 8 System,” serves as a comprehensive introduction to the present day version of the T-Scan technology. T-Scan 8 has revised desktop graphics for simpler clinical display that helps to minimize the T-Scan user learning curve. Chapter 4 is intended to be a *Reader’s Guide* to the many T-Scan images presented throughout this entire book. The reader is encouraged to refer to this chapter’s
images and image captions for illustrated descriptions of the capabilities of the many T-Scan 8 software features. This chapter illustrates to the reader how the T-Scan’s occlusal force and timing software features are displayed and analyzed and what occlusal characteristics they represent. The last portion of this chapter details the three Learning Levels of T-Scan Mastery and necessary clinical user skills that a T-Scan clinician must effectively develop to become a competent T-Scan clinician.

Section 3, “Clinical Use Technologies that Complement the T-Scan System in Daily Dental Practice,” includes chapters that showcase other digital dental technologies, which enhance and complement the T-Scan system’s clinical use. Each chapter includes at least one Clinical Case example that illustrates how to employ these complementary technologies alongside the T-Scan technology. Chapter 5 discusses several dental technologies (in addition to the T-Scan system) that all provide objective, bio-physiologic measurements of different masticatory functions. Surface Electromyography, Magnet-Based 3-Dimensional Electrognathography, and Temporomandibular Joint Vibration Analysis. This chapter also addresses the need for biometric measurement inclusion during the examination of patients and in the assessment of treatment outcomes.

Chapter 6 describes in detail how Joint Vibration Analysis (JVA) technology can measure pathological changes that occur within the Temporomandibular joints. This chapter details how the attributes of the detected TM joint vibrations are representative of various disease states present within the Temporomandibular joint anatomy.

Chapter 7 explains the clinical utilization of the T-Scan 8/BioEMG synchronization system in the treatment of Occluso-Muscle Disorder patients. This chapter describes the neuroanatomy and physiology of how prolonged in time, excursive movement occlusal surface friction induces masticatory muscle hyperactivity and Occluso-Muscle Disorder symptomatology. This chapter also explains in great detail the very therapeutic, rapid, and evidenced-based T-Scan-guided occlusal treatment known as Disclusion Time Reduction (DTR). A significant TMD treatment advance that DTR affords both the patient and the clinician is that it requires no appliance or orthotic device be used, as its highly therapeutic effect results from within the patient’s own neurophysiology.

Section 4, “Occlusal Trauma and Computerized Occlusal Analysis,” describes the consequences of occlusal microtrauma, Dentin Hypersensitivity from occlusal flexure, abfraction formation, and occlusal wear. Each chapter explains how the T-Scan technology can aid in detecting and treating an aspect of occlusal microtrauma. Chapter 8 explains the many differing theories and postulated etiologies of Dentin Hypersensitivity, while introducing a new potential occlusal etiology termed, Frictional Dental Hypersensitivity (FDH). Successful treatment of FDH is illustrated in a pilot study that assessed pre- and post-treatment Dentinal Hypersensitivity changes in patients who underwent Disclusion Time Reduction treatment.

Chapter 9 discusses the detection, diagnosis, and treatment of the clinical symptoms of Cervical Dentin Hypersensitivity (CDH), using the Air Indexing method as a companion to the T-Scan system. Air Indexing quantifies differing degrees of Cervical Dentin Hypersensitivity that can be correlated to occlusal force and timing aberrations detectable on the CDH sensitive teeth with the T-Scan system.

Lastly, Chapter 10 presents the numerous etiologies of occlusal wear, details the clinical consequences of advanced tooth wear, and describes in detail the prosthodontic rehabilitation of advanced occlusal wear. Chapter 10 illustrates that occlusal wear can be successfully minimized when treated and maintained with the T-Scan 8/BioEMG synchronized system.

Section 5, “The Clinical Applications of Computerized Occlusal Analysis,” includes chapters that illustrate T-Scan use in a wide range of clinical scenarios. Chapters 11 through 18 discuss the many
diagnostic, treatment, and maintenance phase advantages, which computerized occlusal analysis offers to clinicians who provide computer-guided occlusal therapy within the differing Dental Medicine disciplines. All chapters in the section include clinical case examples of how the T-Scan can be used in each described discipline.

Chapter 11 explains the T-Scan's role in the case finishing procedures and post-treatment occlusal endpoint assessments of fixed appliance Orthodontic treatment, which often does not produce ideal tooth contacts and ideal occlusal force relationships, despite the orthodontic end result “appearing” visually ideal.

Chapter 12 addresses how the rigid dental implant occlusion can benefit from T-Scan control of occlusal force excess, which can be obtained through timing order corrections that minimize both deosseointegration and implant restorative part material breakage. The T-Scan’s Tooth Timing software is explained in detail, such that readers can understand how to properly implement the time-delay principle in mixed arches with natural teeth near dental implants.

Chapter 13 describes occlusal splint fabrication methodology and the combining of the T-Scan measurements with ink-ribbon occlusal contact markings to greatly improve the force distribution characteristics of a delivered occlusal splint. This chapter addresses the controversy regarding the existence of, or lack of, a relationship between occlusal interferences and masticatory muscle dysfunction, and suggests that the research studies that argue against the existence of a relationship are absent of occlusal measurement and, therefore, lack a scientific basis to deny a relationship exists.

Chapter 14 highlights Centric Relation theory and discusses the clinical technique, advantages, and rationale for identifying the Centric Relation prematurity using either mounted diagnostic casts or the T-Scan system when performing Bimanual Manipulation.

Chapter 15 examines how to employ the T-Scan’s graphical force data in a patient educational strategy that can lead patients to accept needed treatment procedures that would directly benefit them over the long-term. This chapter outlines the four stages of creating optimum dental health, the steps required to perform both effective teaching and learning, the differing learning and teaching styles routinely utilized, and explains how to employ the Feature, Function, and Benefit technique.

Chapter 16 discusses Occlusion as a component of Aesthetic Dentistry by illustrating how the T-Scan can improve the insertion of CAD/CAM machine-milled aesthetic restorations fabricated from digital impressions. The positionally unstable adhesive restoration cannot be tried-in for occlusal contact evaluation prior to bonding them to place. The lack of try-ins compounds occlusal spatial errors, which can be predictably managed using the T-Scan system.

Chapter 17 discusses TENS use in pain analgesia, patient sedation, and as a treatment for Temporomandibular Disorders symptoms when establishing a neuromuscular maxillomandibular relationship. This chapter details how TENS induces a muscularly contracted involuntary arc of closure, where the resultant occlusal contacts can be recorded with the T-Scan guide the occlusal installation of a neuromuscular orthotic.

Lastly, Chapter 18 details the scientific evidence behind the long-standing controversy regarding occlusion’s role in periodontal disease progression. Occlusal force has always been considered to not initiate or accelerate periodontal disease. This chapter suggests that the lack of inclusion of a measurement device for quantifying the occlusion in studies has contributed to the confusion about the relationship between periodontal disease and occlusal force. This chapter illustrates how the T-Scan can improve periodontal treatment results and control periodontal disease during maintenance.

Section 6, “New Occlusal Concepts Based on Computerized Occlusal Analysis,” introduces to Dental Medicine new occlusal parametric concepts that are based upon measured, T-Scan data sets.
Chapter 19 proffers the theory of how occlusal force is delivered to the occlusion through repetitive patterns of force, termed Digital Occlusal Force Distribution Patterns (DOFDPs). Long-term clinical observation has revealed that DOFDP location within the arches coincides with structural adaptive changes in the health of the occlusion, the teeth, the periodontium, and the Temporomandibular joints. The six known DOFDPs are described in detail using many clinical examples that illustrate the dental tissue damage that poor occlusal force distribution can cause.

Finally, Chapter 20 details the Force Finishing concept and protocol to use in minimally invasive, cosmetic, and restorative reconstruction cases. When the force components of a restored dentition are not properly addressed, the signs and symptoms of occlusal force disorders can result in masticatory system breakdown. In contemporary dental practice, where clinicians focus on the aesthetic end-results but place a low priority on the occlusal force finishing, this digital Force Finishing method aids clinicians in predictably and repeatedly achieving occlusal force harmony at case insertion.

Every chapter in the book, *Handbook of Research on Computerized Occlusal Analysis Technology Applications in Dental Medicine*, is a contribution from an international expert who has years of experience working closely with the T-Scan technology within one of the many Dental Medicine disciplines. All chapters contain numerous clinical pictures and companion digital occlusal data images that are both described with matching captions. Additionally, each chapter includes a glossary of Key Terms and Definitions that, together with chapter text, explain each chapter’s focus.

Many chapters address in depth two common themes that persist as controversies in modern occlusal thought. Firstly, the most widely debated occlusal controversy that exists today is whether or not occlusal function plays an etiologic role in the development of Temporomandibular Disorder symptoms. To counter those dentists who opine that occlusion is a non-factor in the etiology of Temporomandibular Disorders, the authors of this book offer to the reader (for his or her own contemplation) that prior to the development of occlusal force measurement with the T-Scan system, the studies that were accomplished on occlusion’s role in Temporomandibular Disorders were markedly flawed because:

- The researchers lacked the capability to measure occlusal function in any quantifiable way and therefore did not know what occlusal problems they were actually treating
- The researchers did know what improvements (or worsening) were made to the occlusion by employing unmeasured occlusal adjustments as treatment within study protocols
- The researchers were unable to properly categorize what occlusal and TMD conditions they were actually diagnosing and treating because they were unable to quantify the occlusal function of the teeth themselves.

Visual assessments of the patient’s intraoral condition and observations of static dental materials that assessed the treatment rendered were the techniques these researchers had at their disposal to attempt to determine occlusal correctness. But their visual assessments were wholly subjective, as were the non-digital occlusal indicators used in those studies.

It is this idea of non-measurement that leads directly to the second controversial issue that plagues the science of occlusion. The current Standard of Care allows clinicians to continue to utilize static occlusal indicators that have no force measurement capability, as if they actually do measure occlusal force by how they look. Add to that the highly error-prone technique of clinician Subjective Interpretation of articulating paper marks and shim stock hold, and the Standard of Care in occlusion today sanctions the use of a non-scientific method that involves clinicians guessing at the paper marks for supposed occlusal
force content. This Standard is antiquated, non-minimally invasive due to the guessing aspect, and is unfounded in science because no published studies exist that illustrate non-digital occlusal indicators can measure occlusal force. Therefore, for the greater good of the human dental patient, this Standard must be changed to include a measured method that is founded in science and is completely absent of clinician guessing.

To that end, each of this book’s authors describe the many exciting and new, computer-based measured occlusal concepts that not only aid in diagnosis and treatment of Temporomandibular Disorder patients but can also be applied to the reconstructed occlusion to ensure prosthesis material longevity, implant survival, and rapid patient adaptation to their new occlusion. These measured treatment approaches have been verified as valid and therapeutic in published studies performed over the past 30 years, and have become available to today’s dental patient solely because of the T-Scan’s capability to measure relative occlusal force and sequence occlusal contact timing.

In shaping this book, I committed myself and tasked the authors to make it a well-referenced and scientifically sound compilation. Only through the scientific efforts of many engineers, authors, and researchers since 1984 has the T-Scan technology evolved and improved to where presently it brings measurement, scientific method, and precision end-point standards to the field of Dental Occlusion, which has been absent of true measurement for the past century.

In conclusion, the diverse and comprehensive coverage within this book will contribute a large volume of never-before-compiled, scientifically based information about the T-Scan technology itself. This book’s pages will undoubtedly lead to improved T-Scan clinical implementation from the world’s user base, as well as lead to a better understanding of the evolving field of Computerized Occlusal Analysis. This book details every available use that the T-Scan technology has in Dental Medicine and therefore can educate many clinicians, researchers, and academicians to the benefits that Computerized Occlusal Analysis offers patients and clinicians. Most importantly, through the dissemination of the information contained within these pages, the clinical practice standards in Dental Occlusion will be elevated from the subjective to the objective.

Thanks to the very hard-working Editorial Advisory Board members, the chapter reviewers, and to the excellent authors who accepted my invitation to create their own chapter that encompassed T-Scan applications in their own dental discipline, readers may now enjoy a singular book concerned with the T-Scan technology and its many applications in clinical dental practice. My hope as the editor is that this book will be a helpful tool for the student who needs an expert reference source for knowledge in the field of Computerized Dental Occlusion and for the clinician and researcher as well, who require clear, concise, and detailed information with which to better understand how to properly employ the T-Scan technology in clinical practice and in research endeavors.

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