Section 1
The History of the T-Scan Digital Occlusal Analysis Systems

Chapter 1
The Evolution of the Science of Measured Digital Occlusion:
From the T-Scan I to the T-Scan 10 Computerized Occlusal Analysis Systems

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ABSTRACT

Since its inception in 1984, computerized occlusal analysis technology has revolutionized both dental occlusal science and daily clinical practice by bringing objective precision measurement to the largely subjectively analyzed dental medicine discipline of occlusion. The science of Measured Digital Occlusion is a major clinical advance over traditional, subjectively practiced occlusion. This is because T-Scan measured timing and force metric-based occlusal function parameters guide both the diagnosis of an occlusion's health, but also aid the clinician in obtaining high-precision, high-numerical tolerance measured occlusal function outcomes, that can't be attained without the T-Scan's capacity to make specific occlusal functional measurements. The development of the T-Scan technology has required much iteration over the past 40 years beginning with T-Scan I, then T-Scan II for Windows®, then T-Scan III with turbo recording, to a simplified desktop version introduced in T-Scan 8, to the present day, state of the art occlusal analysis version known as T-Scan 10 Novus. Numerous authors since the mid-1980s have studied the various T-Scan versions, which inspired the manufacturer to improve the hardware and its recording sensors to be more accurate, repeatable, and precise. The present-day Novus recording handle represents a major ergonomic and functional upgrade over the Evolution handle that was used up to T-Scan 8, while the T-Scan 9 software has evolved into T-Scan 10 Novus system, which includes many new high-tech measurement tools like the Digital Impression Overlay (DIO), the Sensitivity Wizard, the Implant Warning Feature, and the Force Eraser tool. All of these new system modifications improve the clinician's ability to diagnose and treat a wide range of occlusal abnormalities. Chapter one's specific aims are to detail the evolution of the differing T-Scan system versions, and outline the functional measured digital occlusion parameters that have been applied in many scientific patient treatment studies that resulted from important system improvements to the T-Scan's accuracy and repeatability, from version to version. Chapter one will also highlight some newly available digital occlusion technologies that somewhat mimic T-Scan, while including a detailed section comparing and contrasting T-Scan data

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to intraoral scanner (IOS) occlusal representations. Presented studies will illustrate that intraoral scanners (IOS) only prognosticate occlusal contact surface engagement, but do not measure or describe for analysis, occlusal contact force levels or contact timing sequences from within scanned dental arches.

INTRODUCTION

Since its' inception in 1984, Computerized Occlusal Analysis technology has revolutionized both dental Occlusal Science and daily clinical practice, by bringing objective precision measurement to the largely subjectively analyzed Dental Medicine discipline of *Occlusion*. Present day Computerized Occlusal Analysis technology records and quickly displays for clinical interpretation, tooth contact timing sequences and tooth contact fluctuating relative occlusal force levels, which occur during functional mandibular movements. These occlusal data measurements are recorded intraorally with an ultra-thin, Mylar-encased sensor that is connected to a computer workstation via a USB interface. This sensor is placed between a patient's teeth to record changing tooth-tooth contact interactions. This combination of dynamic tooth contact relative force and time data affords a clinician detailed, precise, and unparalleled diagnostic and treatment occlusal measurement data, with which to address many differing clinical occlusal pathologies. The displayed relative occlusal force and timing data aids in the examination and treatment of occlusal abnormalities on natural teeth, dental prostheses, and dental implant prostheses (Kerstein, 2010).

The evolution of this technology has required much iteration over the past 40 years beginning with T-Scan I in 1984, then T-Scan II for Windows® in 1995, to T-Scan III (software versions 5, 6, and 7) in 2004, with development of Turbo recording in 2008, to T-Scan 8 with its simplified graphic display for easier T-Scan user acclimation, to the present day 2018 version known as T-Scan 10 (Tekscan Inc., South Boston, MA, USA). Numerous authors since the mid-1980s, have studied the various T-Scan versions, which inspired the manufacturer to improve the hardware components and the system's recording sensors, to be more accurate, repeatable, and precise. These needed improvements combined with the addition of many relative occlusal force and timing analysis software tools, ultimately negated existing system problems that evoked criticism of the T-Scan system from the Dental Medicine scientific community.

The T-Scan system was developed as a *relative occlusal force measuring system*. All of the T-Scan system iterations (T-Scan I, II, III, T-Scan 8, T-Scan 9, and T-Scan 10) have never recorded or measured, absolute occlusal force in engineering units (calibrated force numbers such as in Newtons per square centimeter, n/cm.^{2} or pounds per square inch, lb./in.^{2}), although some authors have tried to study the T-Scan's capabilities to measure absolute force (Throckmorton, Rasmussen & Calos, 2009; Cerna, 2015). Therefore, throughout the remainder of this book going forward, all references made to *occlusal force*, will be describing *relative occlusal force*, unless otherwise denoted as *absolute occlusal force*.

By measuring relative occlusal force, the T-Scan system(s) detect whether an occlusal force on one set of contacting opposing teeth is greater, equal to, or less than the occlusal forces occurring on other contacting teeth all throughout the dental arches (Kerstein, 2010). Determining relative force is important to the clinician, as relative force illustrates measured differences of varying applied loads upon all contacting tooth locations at any instant within a recorded functional mandibular movement. Relative occlusal force is reported as a percentage of the maximum occlusal force obtained within the recording. Detected relative occlusal force variances can be employed clinically to precisely balance an unbalanced occlusion, by using *targeted time-based and force-based* occlusal adjustments, and can