Minireview Article

Diagnosis of Occlusion with the T-Scan 10 Novus System

Abstract

The physiological restoration of occlusal relationships is important for the normal functioning of the masticatory system. Currently, qualitative and quantitative occlusal indicators are used in clinical practice for occlusion registration. In the past, articulation paper, foil, silk marks, waxes, etc. were the only tools available to access and balance the bite force. However, these methods do not detect simultaneous contact, nor do they quantify time and force. With the introduction of T-Scan, this changes. The evolution of T-Scan from the 1st generation to the 8th generation (1987-2016) has revolutionized the concept of occlusal analysis. The latest version of the T-Scan Novus system, is software version 10.0 that was released in 2018. The T-Scan Novus system is made up of hardware (handpiece, sensor) and Microsoft Windows-based software.

The registered occlusion is transformed by a computer into a dynamic film (dynamic occlusion video). Recorded occlusal contacts are then illustrated as 2- and 3-dimensional graphics. The improved features of the software provide detailed digital information about the occlusal relationships, which enhances the quality of their analysis.

T-Scan Novus helps to avoid errors in the subjective judgment of the dentist and to control changes in occlusal contacts.

Keywords: T-Scan Novus, digital occlusion analysis, occlusal indicators, OccluSense

Introduction

"Static" occlusion can be determined when the lower jaw is closed and stationary, while "dynamic" occlusion is established when the mandible is moving relative to the maxilla (1).

According to Viram U., the term "occlusion" should not be limited to morphological contact between the teeth; rather, it implies a dynamic morpho-functional interaction between all components of the masticatory system - teeth, periodontal tissues, the temporomandibular joint, the craniofacial bones, and the neuromuscular system (2).

The occlusion is individual and depends on the shape, size, and position of the teeth, as well as the size of the dental arch, and the shape and pattern of craniofacial growth (1). Furthermore, the occlusal contacts change constantly. Any interventions in the occlusal relief, any prosthetic restorations or tooth extractions, always presuppose a change in the occlusal proportions. It has been confirmed that even changes as small as 15 μ in the occlusal-

articulating relationship, can lead to significant side effects and must be eliminated (3). In addition, premature occlusal contacts and occlusal-articulating interferences can often cause occlusal trauma, which in turn, can induce changes in the periodontal tissues, teeth, and bone, in the masticatory muscles and the temporomandibular joint. Therefore, it is important to note that the physiological restoration of occlusal relationships is essential for the normal functioning of the masticatory system, and the analysis and evaluation of occlusal contacts are crucial for achieving normal occlusal-articulating relationships (4).

1. Occlusal indicators

Qualitative and quantitative indicators are used in the diagnosis of occlusion (5-8).

Qualitative methods are:

- Articulating paper
- Articulating foils
- Articulating silk
- Metallic shim stock film
- High spot indicator
- Wax
- Alginate impression material
- Silicone impression material
- Occlusal sprays
- Photo-occlusion
- Occlusion sonography

Quantitative methods are:

- T-Scan System
- OccluSense System

In clinical practice, qualitative indicators are most often used due to their ease of application and their low cost. With qualitative methods, only the localization of the occlusal contact points is possible, while their sequence and strength cannot be determined.

According to some authors, the strength of the contacts can be determined by the size and color of the received marking, however, this is not a precise marker of evaluation. They show there is no size and color correlation to occlusal force levels (9-12).

Articulating paper has been widely accepted as the gold standard for diagnosis of occlusion (13).

The sensitivity and reliability of these indicators depend on the thickness, strength, and elasticity of the recording materials, a wet or dry oral environment, and the clinician's interpretation (5, 14, 15), none of which objectively measure occlusal force or applied pressures.

With the quantitative indicators, the sequence, strength, and density of the contacts can be differentiated. There are quantitative measures for determining occlusal-articulating relationships (16, 17).

T-Scan system (T-Scan software version 10, Tekscan, Inc., S. Boston, MA, USA) and OccluSense system (Dr. Jean Bausch GmbH & Co. KG, Koln, Germany) are digital occlusal analysis systems.

The OccluSense system is a new digital occlusion product that was released in 2019. OccluSense system is a wireless digital system, which includes a handle and sensor (figure 1) that transmits the data via a Wi-Fi connection, to an iPad Application. The patient's recording is displayed on the app. Presently, there are no durability, repeatability, or accuracy studies about the OccluSense system sensor, as it has not yet, to date, been tested for its attributes or its capabilities in any published study (8). And, no published OccluSense occlusal treatment research studies exist that have determined how OccluSense data sets can be used safely with patients, to clinically improve an occlusion.

Figure 1. OccluSense System

This review aims to examine the capabilities of the T-Scan Novus system in the diagnosis of occlusal-articulating relationships.

2. History of T-Scan System

Maness developed a new computerized system, known as T-Scan that can record occlusal forces easily and conveniently (16). The evolution of the T-Scan technology over the

past 37 years had its beginning with T-Scan I in 1984, then T-Scan II in 1995, to T-Scan III with software versions 5, 6, 7 in 2004, later with the development of Turbo recording in 2008, and version T-Scan 8 in 2014 (18). The T-Scan handpiece model was updated in 2015 as T-Scan Novus (software version 9.1), and the latest updated one being the T-Scan v10 software version introduced in 2018 (19).

A T-Scan system is a tool for digital occlusion analysis that records and measures tooth contact, force, and timing in real-time using a thin, flexible, pressure-sensitive sensor (20, 21).

3. T-scan Novus System

T-Scan Novus System consists of a recording handle, 2 sizes sensor supports, 2 sizes HD (high definition) Novus specific sensors, and a USB port to connect to a computer or laptop (figure 2).

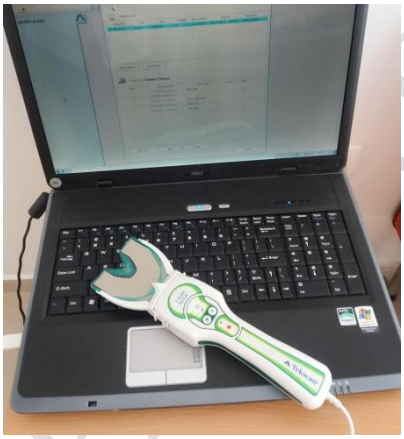

Figure 2. T-Scan Novus System

3.1. T-Scan Novus Handpiece

The T-Scan Novus has a new ergonomically improved handpiece when compared to older versions. Working with it is facilitated by easy-access buttons, which initiate scanning, recording, and a start/stop button, and a recording and computer stand-by indicator located on the upper surface (figure 3). The T-scan Novus hardware consists of a handpiece, support, and a sensor. The recorded occlusal contact data from the sensor is transferred to the software via the handpiece. The sensor supports are placed to the handpiece and the sensor is placed in the supports. The Novus handpiece houses electronics that capture occlusion force data at a standard speed of 175 Hz, and up to 500 Hz in Turbo mode.

Figure 3. T-Scan Novus Handpiece

3.2. T-Scan Sensor

The correct position of the sensor during the occlusion examination is provided by sensor supports, which are available in two sizes - large and small. The T-Scan Novus sensor is 100µ thick and high in resolution (22, 23, 24). The sensor is composed of an electrically conductive network of small square areas sensitive to pressure, called sensels. The differing applied occlusal contact force levels displace the electricity in each load-ed sensel, where high force displaces a lot of sensel electricity, and light forces displace small amounts of electricity. The T-Scan software converts each sensel's amount of electrical displacement into 256 levels of color-coded forces, that describe a patient's occlusal force distribution, which can be played as a dynamic occlusal force video for-wards or backwards continuously, or frame-by-frame (25, 26). The dental sensors are also manufactured in two sizes - large and small (figure 4). Small sensors adjust arch up to 51 mm deep and 58 mm wide and contain 1122 sensels, while large sensors adapt up to 56 mm deep and 66 mm wide and contain 1370 sensels.

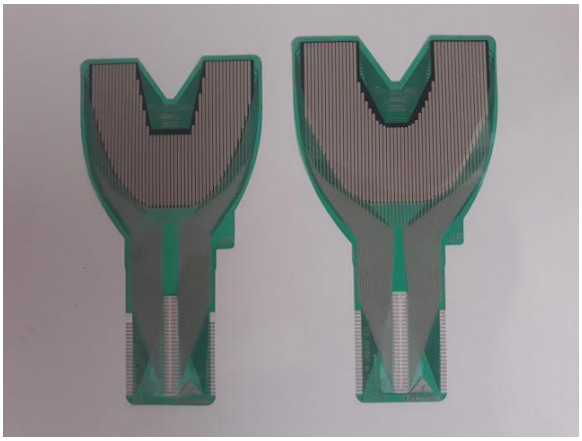

Figure 4. T-Scan Sensor – small and large

3.3. Recording technique

The Novus Handpiece with the sensor and sensor support is placed between the maxillary central incisors of the patient (figure 5). The recording is initiated by pressing the button on the handpiece and the patient is asked to close their mouth until maximum intercuspation is reached. T-Scan also records a patient's left, right, and protrusive mandibular excursions, made from a firm patient closure into their maximum intercuspation.

Figure 5. Proper positioning of the T-Scan sensor

3.4. Data interpretation

The registered occlusal contacts with T-scan Novus are illustrated graphically for analysis in two or three-dimensional images (figure 6), or as a video that can be analyzed step by step. The software transforms the data and displays it as images in different colors in a graphical model of the two dental arches (dynamic occlusion video). The strength of the

occlusal contacts is shown in a different color, for instance -the maximum force is shown in red and pink, the medium force is shown in green and yellow, and the minimum force is shown in blue.

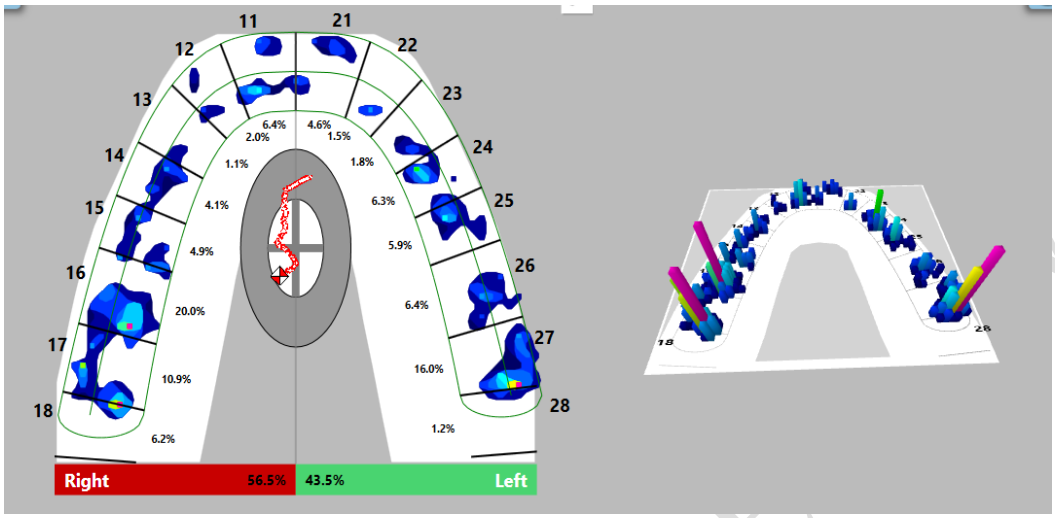

Figure 6. Dental aches in 2D and 3D view

For better analysis of the distribution of occlusal forces, the dental arch model is divided into four quadrants: right - anterior and posterior, left - anterior and posterior, marked in different colors (red, green, blue, and yellow) (figure 7).

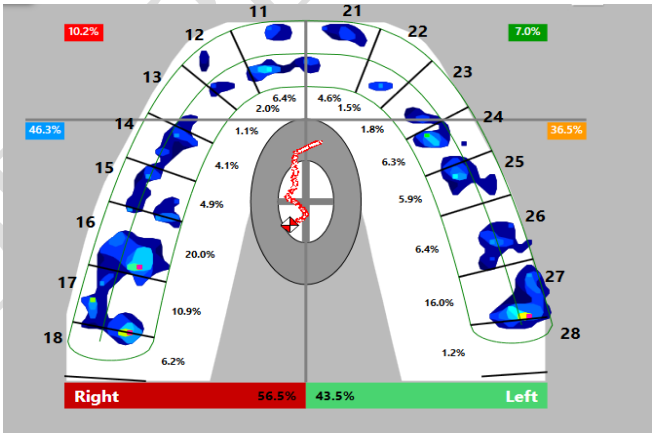

Figure 7. Arch model into four quadrants

The T-Scan Novus shows patient parameters, such as:

- first contact;
- maximum bite force;
- maximum intercuspation;

- the center of force and its trajectory, which indicate the balance of forces during occlusion;
- occlusal forces in % for the left and right sides of the dentition.

The numbers of the teeth are indicated on the outside of the Arch Outline, while the inside of the Arch Outline shows the occlusion force in percentages (figure 8).

Digital examination of the occlusion not only helps the clinician to accurately analyze the occlusal relationships but also engages the patient's attention and curiosity. The patient visually assesses their own uneven distribution of occlusal force through the different colors of the registered contacts (18).

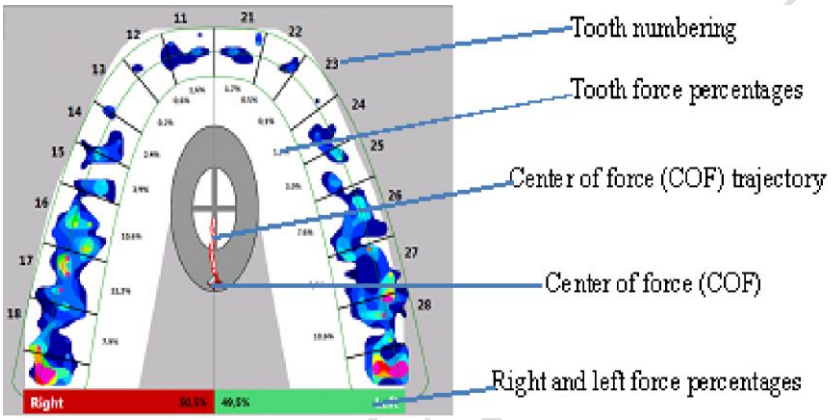

Figure 8. 2D Force View

The Force vs. Time graph displays the force, relevant to the time for the patient's overall bite, from the first contact up to the end of the record (figure 9). Each graph line is color-coded to provide an easy visual reference to areas of the Arch Model or teeth.

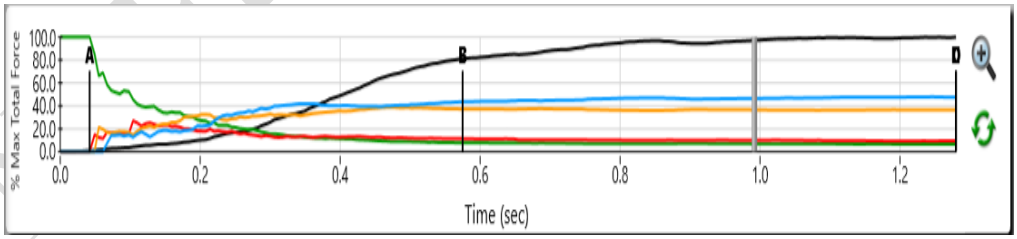

Figure 9. A Force vs. Time graph describing the force changes as a patient closure into Maximum Intercuspation (MIP) (A-B period); the completely holds their teeth intercuspated in MIP (B-C period), and then makes an excursive movement to the left (C-D period). The 4 colored lines are matched to the 4 quadrants shown in Figure 7, and describe the individual quadrant force changes during the entire recorded mandibular event. The Black Total Force Line describes the Total Force changes of the entire mandibular event.

The Timing Table below shows the time of occurrence of the occlusal contacts and the force applied during the contacts. The line from point A to B denote the start and end of the Occlusion Time (OT) and the line from point C to D denote the start and end of the Disclusion Time (DT) (figure 10).

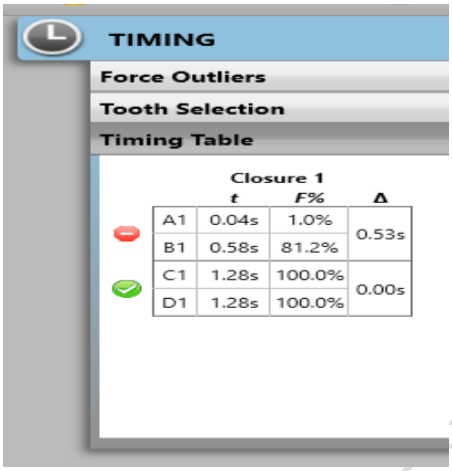

Figure 10. The Timing Table calculates the Occlusion Time (OT) duration of a patient closing into Maximum Intercuspation (MIP) (the A-B period; Figure 9), and the Disclusion Time (DT) of mandibular excursions (the C-D period; Figure 9). When one or both are too long, warning symbols appear that alerts the clinician these values are non-physiologic

The Occlusion Time (A–B) is the elapsed time in seconds, measured from the first tooth contact until the last tooth contact. Maximum intercuspation always occurs before the patient achieves maximum bite force. The OT describes the degree of bilateral time simultaneity present in a patient's occlusion. The ideal duration of OT is ≤0.2 s.

The Disclusion Time is the elapsed time in seconds, measured from the beginning of an excursive movement made in any direction (left, right, or forward) with all teeth in maximum intercuspation until only canines and/or incisors are in contact. The ideal duration of DT is ≤0.5 s (27).

The T-Scan also features Warning Alarms for occlusal overloading of implants, and when poor recordings are made (figure 11). Implant Loading Alerts provide immediate feedback on implant loading that may be a concern.

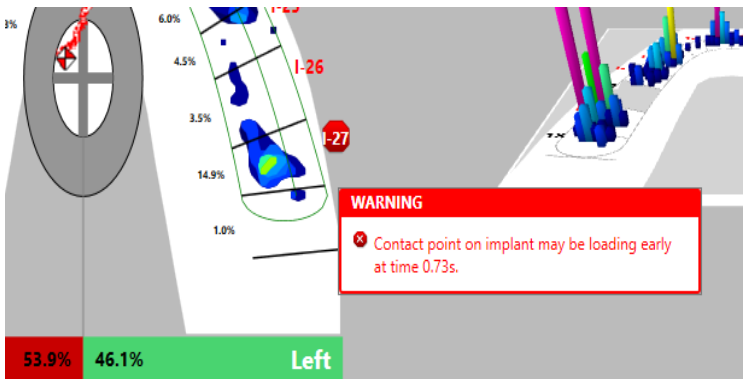

Figure 11. Implant Loading Alerts

T-Scan can be synchronized with Electromyography software in real-time that measures up to 8 masticatory muscles.

An additional software option could be Digital Impression Overlay. It allows us to observe the occlusal force and timing data superimposed over a digital impression, following the importing of an **stl.** files of an intraorally-scanned dental arch into the Patient Record (figure 12) (18).

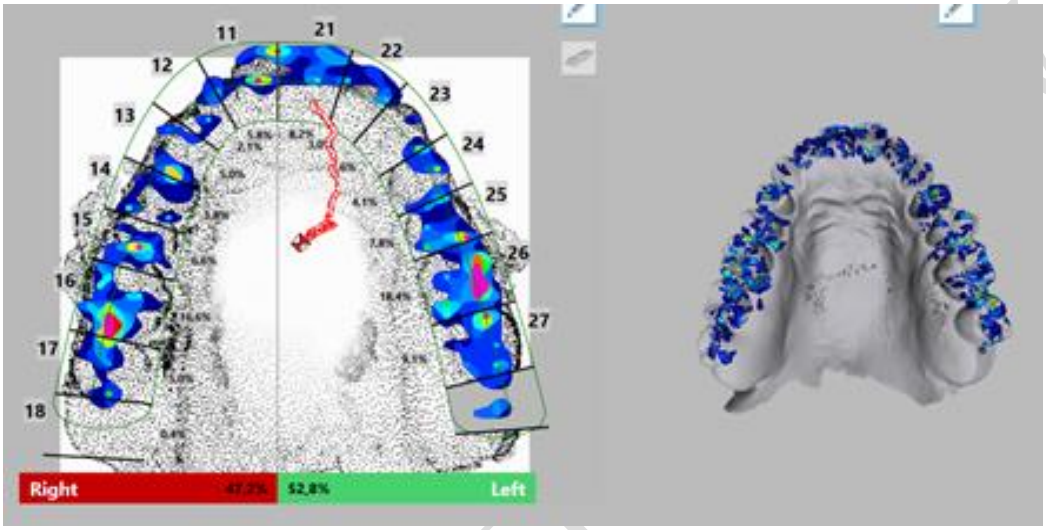

Figure 12. Digital Impression Overlay

3.5. Application of T-Scan Novus System

The T-Scan Novus system can be used in any clinical situation where bilateral simultaneous occlusal contact is beneficial (7, 28-33), and where friction-free excursive movements will enhance chewing function, and optimize masticatory muscle physiology.

- Removable complete dentures
- Fixed or removable partial dentures
- Complete arch reconstruction solely using implants
- Natural tooth occlusal equilibration
- Disclusion time reduction
- Temporomandibular disorders
- Orthodontics
- Abfraction formation and root recession
- Occlusal trauma
- Locating painful teeth
- Occlusal splints

3.6. Benefits of T-Scan System (34, 35)

- Improved diagnosis

- Increased quality of patient care
- Enhanced patient motivation and education
- Reduced treatment time
- Storing patient data
- Reduced risk of implant failure, unstable dentures, traumatized teeth, ineffective splints, porcelain fractures.

Conclusion

The new and improved functions of the T-Scan Novus software provide digital information about the occlusion which allows for more accurate analysis.

T-Scan Novus helps to avoid errors in the subjective judgment of the dentist and to control changes in occlusal contacts.

The indicated capabilities of the digital occlusion analysis system show that T-Scan is a better occlusal indicator compared to other non-digital indicators.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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