Review Paper

ROLE OF T-SCAN IN DIGITAL OCCLUSAL ANALYSIS - A REVIEW

Abstract:

Occlusion analysis is important to analyze any disharmony in occlusion. It constituted a great difficulty to analyze the problems arising from occlusal origins due to the complex nature of the human occlusal system. The search for the most atraumatic dental occlusion is growing demand and it lead to development of T-scan. It provides both qualitative and quantitative assessment of occlusion. Instead of the former messy qualitative carbon marks and it is presented in a video (movie) format. The system makes it simple to operate, dynamic viewing of occlusion, timed analysis of force during various positions of teeth contact and the possibility of permanent documentation and monitoring of the occlusal condition after carrying on the various treatment protocols. The T-Scan presents a valuable method for clinical evaluation and understanding of the occlusal problems. The purpose of this review paper is to provide an overview of system over its utility in advance treatment modalities

KEY WORDS- Occlusion, T-scan, Occlusal analysis

INTRODUCTION

Based on the glossary of Prosthodontics terms (2005), Occlusion is "the static relationship between the incising or occlusal surfaces of the maxillary or mandibular teeth or tooth analogues. The occlusion should be stable and as stress free as possible". For appropriate functioning, occlusal contacts must be in synchronization with the stomatognathic system. The idea of occlusion is not restricted to morphological contact interactions between teeth. It embraces the dynamic morphofunctional interactions amongst all constituents of the masticatory system, including teeth, periodontal tissues, the neuromuscular system, the temporo-mandibular joint and the craniofacial bones. [1]

Occlusal contacts are made when mandibular teeth come into contact with maxillary teeth. Nearby contacts are those areas that range from a contact to a gap of 0.5 mm between the occluding surfaces, while noncontacts are those areas wherein there is a 0.5-2 mm separation of the teeth. Among the several occlusal concepts existent, the more accepted one is the bilateral balanced occlusion introduced by Bonwill. Occlusal contact marking indicators are used to determine the specific areas of this occlusal contacts. These indicators are made of different materials that on occlusal contact transfer color from the indicator to the occlusal contact area. [2]

The true occlusal contact time by description suggests that a time of 0 s elapses between the first and the last occlusal contact, i.e., all the occluding surfaces should encounter at the same instant during the mandibular closure. Occlusal therapy aims at achieving this simultaneous occlusal contact relationship. T-scan occlusal analysis system provides one option to assess occlusal forces (Chapman and Kirsch, 1990). The T-Scan system is a computerized dental device which can quantitatively analyze occlusal contacts (position, strength, and frequency of occlusal contacts). [2]

This review will throw light upon T-scan technology in detail, its functional aspect and multi-disciplinary approach to deliver better services to patient.

History of T-Scan

In 1987, Tekscan developed *T-Scan*, the first ever grid-based sensor technology precisely designed for occlusal analysis. Tekscan created this powerful diagnostic tool in response to the need of dentists seeking an accurate way to dynamically measure occlusion. [2]

The evolution of pressure sensitive ink - Mylar encased sensor technology, was introduced with the T-Scan® I computerized occlusal analysis system by Maness et al in 1984. In 1987, Tekscan developed *T-Scan*®, the first ever grid-based sensor technology specifically designed for occlusal analysis. Till now the advancement has reached up to t-scan version -5. [2]

T –SCAN SYSTEM

T-Scan is a computerized occlusal force analysis device. It is an essential part of clinical functional analyses in prosthetic and restorative insertions. The T-Scan computerized system can rapidly determine prematurity, high points, regions of excessive force and non-uniform force concentration. It can also analyze dis occlusion time accurately. The evolution of pressure sensitive ink - Mylar encased sensor technology, was introduced with the T-Scan I computerized occlusal analysis system by Maness et al in 1984. [3]

It was developed as the first ever grid-based sensor technology specifically designed for occlusal analysis. Till now the advancement is reached up to t-scan version -5. The occlusal data is characterized as dynamic 2D and 3D images with colored columns ranging from BLUE (optimum force) to RED (high force) seen on the computer screen when the patient bites on the occlusal sensor **(Fig 2).** This measurable occlusal data enhances the clinician's ability to make precisely targeted adjustments during occlusal equilibration following prosthetic, restorative, orthodontic or implant procedures. T-Scan III software version 8.0 is the latest generation of this occlusal analysis technology **(Fig 1)** that permits the clinician to record and explore the patient's occlusion with precision.

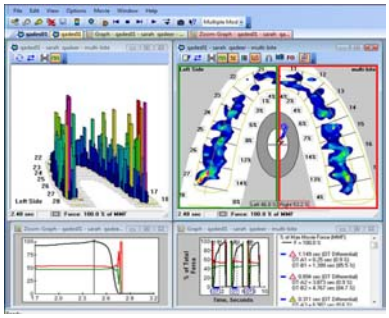


Fig 1 **Fig 2**

Fig 1. T-Scan III System with Version 8.0 graphic
Fig 2. T-Scan Multi-bite Screen Capture showing 2D, 3D, Graph and Zoom Graph Window

Assembly:
The system components include a sensor and support, a handle assembly, the system unit, computer software and a printer. The T-Scan permits the quantification of occlusal contact data by registering parameters such as bite length as well as the timing and force of tooth contact, and stores the data on a hard drive which can be played incrementally for data analysis in a time-based video. [3]

Sensor
The sensor is the key component. It is 60 micrometers thick and made of a polyester film. T-Scan sensors are available in two sizes:

1. Large and
2. Small.

Large size sensor can accommodate arch up to 66 mm wide and 56 mm deep and contains 1370 sensels whereas small size sensor can accommodate arch up to 58mm wide and 51mm deep and contains 1122 sensels. The thickness of the sensor is 0.1mm^3. Table 1 shows the sensor specifications.

The patient bites of a thin (75 micron) sensor. The sensor is made up of columns and rows of pressure sensitive ink, trapped in a Mylar sandwich (**Fig 3**). The sensor is attached to a handle which scans at thousandth of a second time intervals. The handle reads the data from the sensor and passes it to the computer software which presents the data in an easy to understand visual display.

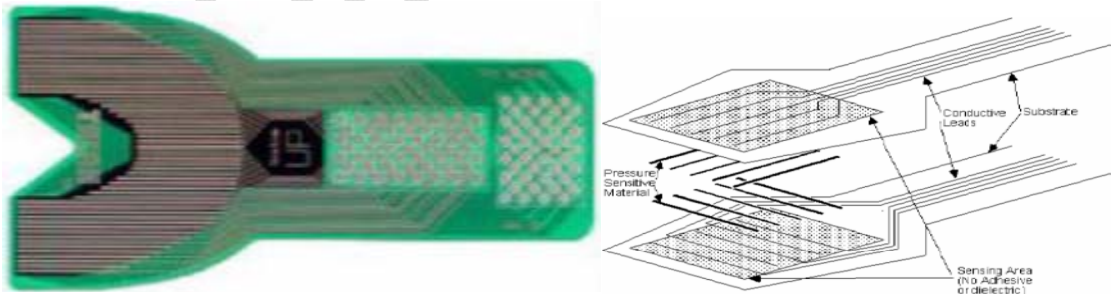


Figure 3 showing sensor and its layers

Table. 1. Sensor specifications

Actuation force	0.1 N
Force sensitivity range	0.1 N to 100 N
Size	7.62 mm in diameter
Non actuated resistance	10 Mega ohm
Thickness range	0.2 to 1.25 mm
Number of actuations	10 million tested (without failure)

The system can be operated on two modes, time analysis and force analysis.

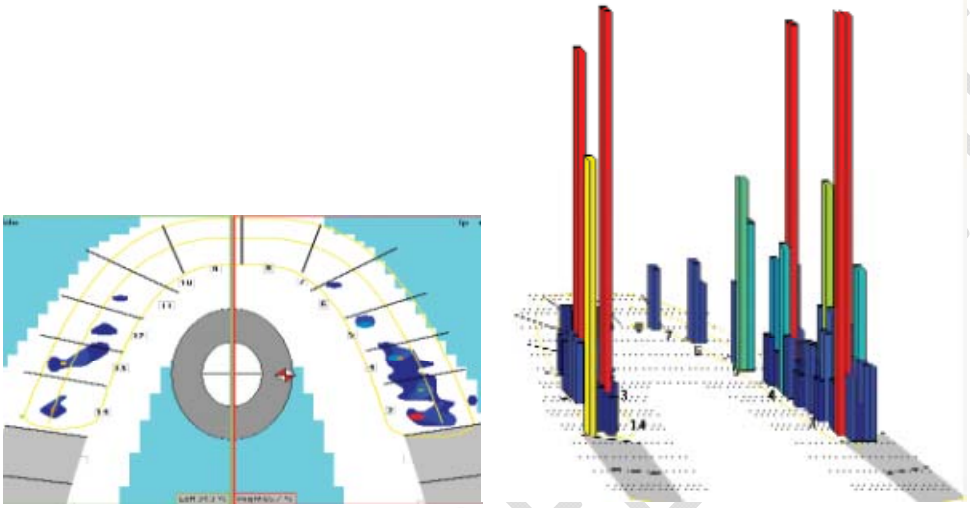
Time ana!ysis. This mode gives information on the location and sequence of occlusal contacts, showing in a different color the location of the first, second and third or more contacts (Fig. 1). On the top of the monitor screen is displayed the timing of each successive contact with regard to the first.

Force analysis. This mode offers the operator with data on the location and relative force of tooth contact. On the bottom of the screen, bite length can be read.
Within force analysis, two additional modes can be selected, instantaneous (which registers mandibular positions) and sequential (which registers the intensity of contacts during mandibular movement). [7]

Recording technique - The recording handle with the sensor and arch support is placed between the maxillary central incisors of the patient. The recording is initiated by pressing the button on the recording handle. The patient is asked to close the mouth till complete intercuspation is reached, without making any excursive movements. For this, the sensor is inserted into the patient's mouth in such a way as to make its support aligned centrally with the midline of the

upper incisors. The patient is then asked to bite on the sensor in a maximum intercuspation position. After the handle button is pressed the arch model is automatically created on the screen. It should be taken into account that this model is an approximation of the patient's arch and therefore uncertainty exists as to the exact location of the contact on the screen. [2]

Data interpretation - The data recorded is shown as a force film, [figure 4] in which the center of force trajectory shows the history of the path of the center of the force from the beginning of the force movie recording to the current displayed frame. [2]



2 D view 3 D view

Figure 4. Showing 2 dimension and 3 dimension view of occlusal contacts

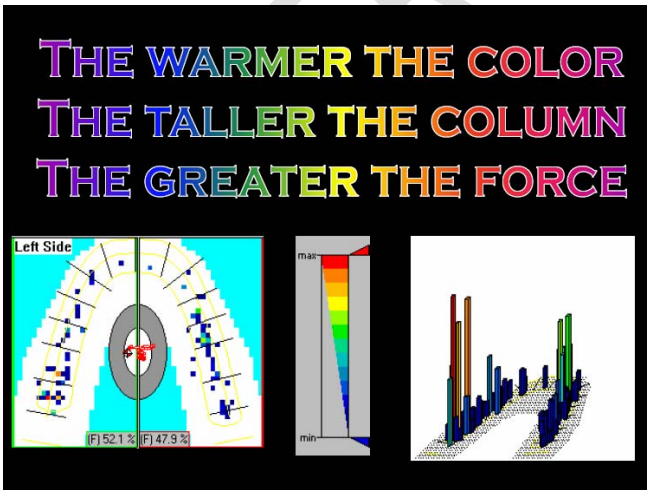


Figure 5. Showing force distribution on individual teeth.

Thus, by gaining information on the earliest occlusal contact, it can be adjusted and simultaneous occlusal contact can be established [figure 4], [figure 5]. The consequence of this occlusal therapy is that the patient can feel a more widespread contact sensation at the end, the reason being that the establishment of true and measurable bilateral simultaneous occlusal contacts is achievable using the T-Scan.

Application of T-SCAN

Application of T-scan is seen in various fiels as Fixed & Removable Prosthetics, Implant Prosthetics TMD Appliances, Occlusal Equilibration, Disoclusion Time Reduction, Abfraction Management, Periodontal Management, Differential Diagnosis, Orthodontics, Locating Painful Teeth and Dental Case Finishing, Research.

Table 2: Applications of T-Scan

FIELD	USES
Case Finishing	As articulating paper does not measure force, balance, or timing, it is not a sophisticated enough media to rely on. T-Scan allows a clinician to case finish with accuracy and confidence.
Diagnostic Screening	Occlusal trauma is the reason of a large number of pathologies in the mouth. Measuring the force and timing of a functional bite is essential for accurate diagnosis. T-scan acts as valuable tool in diagnosing occlusal trauma.
Implantology	The T-Scan shows in thousands of a second time intervals how force is applied to adjacent teeth and implants. T-Scan occlusal analysis system is helpful to meet the needs of patients for reliable measurement of occlusal biting forces.
Orthodontics	One of the goals of orthodontic treatment is to improve occlusion achieving proper bite force. The use of T-scan before and after orthodontic treatment for every patient helps to attain the goal of correcting malocclusion and maintaining the proper bite force.
	Prolonged disoclusion time, frequency of

Temporomandibular Disorder	premature contacts and asymmetry in the occlusal force,and intracapsular joint disorder lead to numerous temporomandibular joint related problems. The application of T-Scan and kinesiographic techniques in combination with electromyography is of great value to the clinician for substantiating certain clinically hard-to-evidence factors.
Prosthodontics	Replacement of single or multiple teeth with crown, bridge, complete or partial denture is routinely performed in dentistry to attain proper function and esthetics. Improper occlusion is a major challenge. The T-Scan system was found to be clinically useful as a diagnostic screening method for occlusal stability of intercuspal position.
Research	1. In 1992 Lyons MF, Sharkey SW, Lamey PJ found, in a clinical study evaluating the T-SCAN system for measurement of occlusal forces, that the system was unable to measure them accurately although it can still serve as a useful clinical tool.[11] 2. In Bulgaria, Kalachev conducted a number of studies on the occlusal-articulation relation in intact dentition during articulation with T-SCAN II elucidating the relationship between occlusal load and periodontal stress.[12] 3. Kerstein RB et al. consider the T-SCAN III system to be a highly accurate technique to study and analyse the occlusal and articulation relations.[13] 4. Koos supports the view that the system has certain advantages in terms of accuracy, reproducibility and visualisation of the dental arches.[14]

	5. In a study by Jimoh Olubanwo et al, the usefulness and consistency of T-Scan in assessing occlusion before and after orthognathic surgery was investigated. And they concluded that T-Scan is good for assessing occlusal discrepancies and can be used to portray the pre- and postoperative occlusal contact distribution during treatment planning and follow-up.[15]

Table 3: Benefits and Limitations of T-Scan system

Benefits	Limitations
• Improved diagnosis • Increased quality of care • Decreased treatment time • Increased comfort of dental prosthetics • Reduced risk of implant failure, traumatized teeth, unstable dentures, ineffective splints, and porcelain fractures • Legal documentation of outcome • Enhanced patient education • Build your practice • Increased referral business from otherphysicians	• Thinner occlusal registration materials provide more stable records of the contact points. To fulfill the technological demands, the T-Scan sensors are made as thin as possible (0.1mm) which is still relatively thicker as compared to occlusal indicators like articulating silk. • The sensors may be damaged when forces are concentrated over a small area, such as, a sharp tooth cusp. This may lead to inexact recording of the occlusal contact and/or artifacts in the produced images. • The T-Scan system is able to duplicate occlusal interferences only exceeding 0.6mm in dimension. • Also, the two unlike modes of the system (force and time analysis modes) may mimic different occlusal contact data. Time mode has been shown to register the maximum number of contacts, while the force mode has been shown to current the least variability. However, these variances are small.

Conclusion:

The T-Scan system has proved to be a dependable method for the analysis and evaluation of occlusal contact distribution in maximum intercuspation. Though its cost is very high but it is a valuable method for clinical evaluation and understanding of the occlusal difficulties but also it offered an important tool for teaching purposes.

The data is obtain from T-scan can be analyzed in three ways

1. It shows the duration and relative magnitude of all tooth contacts
2. It identifies disproportional loading forces and transient impact forces acting on specific teeth and
3. It identifies active tooth contact occurring within the functional range of mandibular movement and the interaction between working and nonworking interferences.

T-Scan system regulates sufficient sensitivity and specificity as a diagnostic tool and presents higher reliability in intra-oral conditions with presence of saliva. This technology reduces the subjective interpretation of occlusal analysis data and also provides registration of dynamic

occlusal information. There is a need to conduct randomized controlled trials to quantify the benefits of T -Scan over traditional methods. Patient-centered approach to studies will also assist in understanding their apparent TMJ improvement after the treatment conducted using T-Scan system.

References:

1. Viram U, Arora A, Kapur DS, Anika K. T-SCAN: Occlusion demystified. UJMDS 2015; 3[1]: 1-5
2. Dr. Kirti Somkuwar.A descriptive quantitative computerized occlusal analysis system: T-scan. IJAR 2015; 3[4]: 508-513
3. Pyakurel U, Long H, Jian F, Sun J, Zhu Y, Jha H, Lai W. Mechanism, accuracy and application of T-Scan system in dentistry-A review. J of Nep Dent Assoc 2013; 3:1-5.
4. Vinoth Kumar G, Antony Fernandes, Lalith Radhakrishnan Et al. Occlusion Analysis using T- Scan Technology.JCHPS 2017;11: 126-129
5. The glossary of prosthodontic terms. J Prosthet Dent.2005; 94(1): 10-92.
6. Jain R, Jabbal R, Bindra S, Aggarwal S, Jain R. T-Scan a digital pathway to occlusal perfection: a review. Annals of Prosthodontics and Restorative Dentistry. 2015;1(1).
7. Cartagena AG, Sequeros OG, Garcia VG. Analysis of two methods for occlusal contact registration with the T-Scan system. Journal of oral rehabilitation. 1997 Jun;24(6):426-32.
8. Bozhkova TP. The T-SCAN system in evaluating occlusal contacts. Folia medica. 2016 Jun 1;58(2):122-30.
9. Ashish,Mukesh,Avinash Et al. T-Scan A digital occlusal analyser. TMU J Dent. 2017;4.
10. Dickerson WG, Chan CA, Carlson J. The humanstomatognathic system: a scientific approach toocclusion. Dent Today. 2001;20(2):100-2, 4-7.
11. Lyons MF, Sharkey SW, Lamey PJ. An evaluation of the T-Scan computerised occlusal analysis system. Int J Prosthodont 1992;5(2):166.
12. Kalachev Y. Occlusal pressure and strain in the periodontium – analysis and recommendations for clinical use [dissertation] Faculty of Dental Medicine, Medical University, Plovdiv; 2003 (Bulgarian).
13. Kerstein RB, Thumati P, Padmaja S. Force Finishing and Centering to Balance a Removable Complete Denture Prosthesis Using the T-Scan III Computerized Occlusal Analysis System. J Indian Prosthodont Soc 2013;13(3):184-8.
14. 14. Koos B, Godt A, Schille C, et al. Precision of an instrumentation-based method of analyzing occlusion and its resulting distribution of forces in the dental arch. J Orofac Orthop 2010;71(6):403-10.

15. Agbaje JO, Van de Casteele E, Salem AS, Anumendem D, Shaheen E, Sun Y, Politis C. Assessment of occlusion with the T-Scan system in patients undergoing orthognathic surgery. Scientific reports. 2017;7(1):5356.