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Reviewing the Advantages of T-SCAN System III as a Digital Occlusal Analysis System in Restorative Dentistry

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Abstract:- This comprehensive review article thoroughly investigates the benefits of utilizing the T-SCAN System III as a digital occlusal analysis tool in restorative dentistry. It encompasses a detailed examination of the system's evolutionary trajectory, including its various versions and generations, alongside comprehensive descriptions of its individual components and practical applications. Furthermore, it explores the system's wide-ranging utility in dentistry, serving as both a diagnostic aid for identifying occlusal issues and an assessment tool for validating patient occlusal integration of restorations in both static and dynamic occlusions. By conducting a meticulous analysis of existing literature, this paper aims to offer valuable insights into the effectiveness and potential limitations of the T-SCAN System III, highlighting its crucial role in enhancing occlusal analysis and treatment outcomes in restorative dentistry.

Keywords:- *T-Scan System III, Occlusal Analysis, Digital Dentistry, Restorative Dentistry, Dental Technology, Review.*

I. INTRODUCTION

Occlusion in dentistry encompasses more than just the physical contact between the biting surfaces of opposing teeth or their replacements. It refers to the contact of teeth in opposing dental arches when the jaws are closed (static occlusal relationships) and during various jaw movements (dynamic occlusal relationships). The occlusion of teeth plays a crucial role in oral function, yet it is often overlooked or taken for granted in patient treatment. Successful restoration of the mouth with any dental intervention depends on maintaining occlusal harmony. Occlusion involves a multidisciplinary understanding of the scientific and clinical factors underlying mandibular function and dysfunction. This approach aligns with the principle that the primary goal of dentistry is to preserve the functional integrity of the masticatory system. This concept attracts attention from various dental specialties, including Prosthodontics, Oral Surgery, Implantology, Periodontics, Pedodontics, and Endodontics. Traditionally, occlusal-articulation relationships have been recorded using various occlusal analyzers. Among these, articulating paper has been widely used in dentistry as a diagnostic technique to identify points of contact between upper and lower teeth. [1-2].

Recently, T-Scan has emerged as a popular and reliable clinical diagnostic tool for measuring and assessing occlusal contact force. It accurately detects occlusal contacts, which occur when the lower teeth make contact with the upper teeth. Areas without contact, known as noncontacts, have a separation of 0.5-2 mm between the contacting surfaces of the teeth, while nearby contacts occur when there is a contact or a breach of 0.5 mm between occluding surfaces. [3].

Bilateral balanced occlusion, initially proposed by Bonwill, remains one of the most recognized occlusal concepts in current practice. Annual occlusal adjustments and articulating interferences can result in occlusal traumas, leading to alterations in the masticatory muscles, temporomandibular joint, and supporting dental tissues.

To precisely evaluate occlusal relationships and force in real-time, dentistry has developed a computerized occlusal analysis system known as T-scan. This innovative technology assists in diagnosing occlusal discrepancies and guiding treatment decisions. Additionally, it serves as a final check after any dental intervention to ensure optimal occlusal function and harmony. [4]

The objective of this article is to explore the benefits and applications of the T-SCAN System III in restorative dentistry, focusing on its evolution, composition, mode of action, practical usage, and effectiveness as a diagnostic and evaluative tool for assessing occlusal integration.

II. T-SCAN'S EVOLUTION: THROUGH VERSIONS AND GENERATIONS

Throughout its 25-year evolution, the T-Scan system has become an indispensable analytical tool for determining optimal occlusal patterns, leading to improved treatment outcomes. The initial version, known as the first-generation (G1) sensor, underwent several design revisions to enhance its registration capacity. Developed by Tekscan in 1987, the T-Scan system introduced the pioneering grid-based sensor technology exclusively tailored for occlusal analysis. Prior to

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this innovation, the T-Scan® I system, unveiled in 1984, demonstrated advancements in pressure-sensitive ink-Mylar encased sensor technology by Maness et al. Subsequent advancements included the introduction of the T-Scan II system for Windows in 1995, followed by the T-Scan III system (software versions 5, 6, and 7) in 2004, featuring a high-definition (HD) sensor with increased sensitivity and a thinner profile. The introduction of turbo recording in 2008 marked a significant advancement, eventually evolving into the latest iteration, T-Scan 8, released in 2014. In 2015, the T-Scan handpiece model underwent an update to become the T-Scan Novus (software version 9.1). The most recent enhancement, T-Scan version 10 software version, debuted in 2018, continuing to refine this essential tool for occlusal analysis in dentistry. [2-6].

III. DESCRIPTION OF THE COMPONENTS OF T-SCAN SYSTEM III

The T-Scan system comprises various components, including a sensor and its support, a holder assembly, the system element, computer software, and a laser printer. Housed within a handheld device, the U-shaped sensor connects to a computer via a USB port and is inserted into the patient's oral cavity between the occlusal surfaces of their teeth. By recording factors such as bite length, timing, and force of tooth contact, the T-Scan system quantifies occlusal contact data. [7].

This data is stored on a hard drive and can be played back incrementally for analysis using time-based video playback features. Fig. [1]

Fig. [1]: Components of T-SCAN System III

The system's sensor serves as the primary tool for recording occlusal registration, precisely measuring quantitative occlusal biting forces, and capturing the timing and force of each occlusal contact. Available in small and large sizes to accommodate arches of varying dimensions, the sensor comprises a 60-micrometer thick polyester film. The ultra-thin (0.004-inch, 0.1-mm) reusable sensor used in T-Scan III v10 features a structural design comprising two coats of Mylar sandwiched together by a lattice of resistive ink rows and columns. Calibration ensures reliable registration of absolute bite forces, converting the sensor output into absolute force units during biting tests in human participants. [9].

The sensor, attached to a handle, scans at intervals of one thousandth of a second, enabling precise data collection. Fig. [2]

Fig. [2]: T-SCAN System III Inserted into the Patient's Oral Cavity

IV. THE OPERATIONAL DYNAMICS OF T-SCAN SYSTEM III:

The T-Scan III system facilitates digital occlusal analysis in both static and dynamic conditions, offering valuable insights into the distribution of occlusal forces across dental arches in diverse clinical scenarios. It evaluates occlusal contacts from initial contact to maximum intercuspidation, enabling the identification of traumatic occlusal contacts and assessment of relative force levels. The system provides two operational modes: time analysis, displaying color-coded occlusal contacts with timing information, and force analysis, presenting data on tooth contact position and relative force, including bite length. [6-8].

In the analysis window, three-dimensional (3D) colored bar graphs illustrate the relative occlusal force, while a two-dimensional (2D) dental arch display outlines occlusal contact forces in yellow, indicating contact locations and force levels. Force vs. Time graphs depict changing occlusal force percentages over time for both arch halves, aiding in understanding force dynamics. Fig. [3]

The sensor, positioned between the central incisors parallel to the occlusal plane, accurately records information about each dental arch element and its absence, measuring recording length and sensitivity levels. Before recording begins, the sensor undergoes adaptation through masticatory actions. Recorded forces are stored on hard drives for subsequent analysis.

T-Scan SYS III technology facilitates recording of various mandibular movements, such as centric relation, habitual intercuspation, and excursive functional movements. These capabilities support comprehensive analysis of occlusal dynamics and contribute to treatment planning for optimal occlusal function. [5-9].

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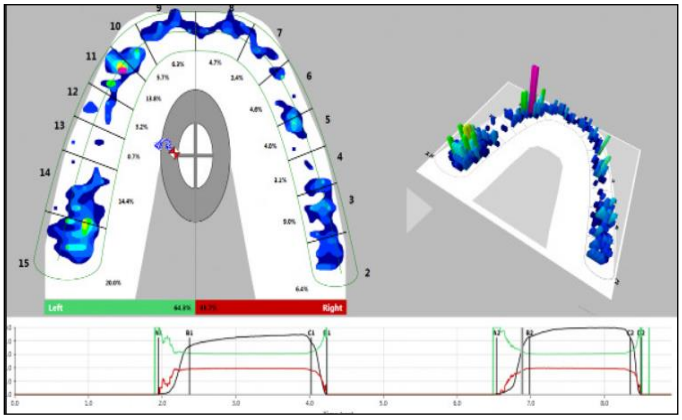

Fig. [3]: T-Scan System III Playback Desktop of a Maxillary Arch Digital Scan Overlaid with Color-Coded Force Data

V. T-SCAN SYSTEM CLINICAL APPLICATIONS

The T-Scan system plays a pivotal role across the entire spectrum of dental care, serving various functions from initial diagnosis to treatment planning and continuous monitoring within the field of dentistry:

➢ *In Restorative Dentistry*

Achieving optimal occlusal integration of direct coronal restorations, whether composed of resin, composite, or amalgam, is crucial for long-term success and patient comfort.

The T-Scan system serves as a valuable tool in this process by providing detailed insights into occlusal dynamics post-restoration.

By analyzing bite force distribution, timing, and occlusal contacts, T-Scan enables clinicians to assess the harmony of the restoration within the patient's occlusion. This real-time feedback allows for immediate adjustments if discrepancies are identified, ensuring that the restoration aligns seamlessly with the patient's occlusal function. [10].

➢ *In Conventional Dental Prosthodontics*

In conventional dental prosthodontics, permanent restorations, regardless of their design (such as crowns, bridges, veneers, inlays, etc.) or materials (ceramic, composite), must establish a physiologically stable occlusion that accommodates both static and dynamic occlusal forces. Various occlusal analyzers have been utilized in dentistry, categorized as quantitative and qualitative gauges, to assess occlusal-articulation relationships.

Research, exemplified by studies like that conducted by Halili et al., highlights the effectiveness of T-Scan computerized occlusal analysis in providing measurable occlusal load and timing statistics, thereby enhancing the protection of dental ceramics and improving patient comfort. Bozhkova et al. further emphasize how T-Scan technology translates qualitative data into actionable insights, digitally representing precise evaluations of occlusal interactions. Similarly, Vladutu et al.'s study utilizing T-Scan III technology reveals a positive correlation between occlusal connections and masticatory muscle activity in individuals with bruxism, as measured by surface electromyography. These findings underscore the valuable role of T-Scan in optimizing occlusal function and facilitating successful dental prosthetic treatments. [2-8].

➢ *In Pediatric Dentistry*

In the field of pediatric dentistry, the emergence of digital dental technologies has provided valuable tools for assessing and managing dental issues in children. Among these advanced technologies, the T-Scan computerized analyzer stands out as particularly beneficial for detecting occlusal discrepancies in young patients.

Studies, such as those conducted by K. Okamoto et al., have underscored the repeatability and clinical applicability of the T-Scan system in children. For instance, Gallangher et al. conducted research to investigate the impact of stainless steel crowns (SSC) on extreme intercuspation locus in children, as well as the effects of local anesthesia on the child's ability to reach Maximum Intercuspation Position (MIP). In these studies, occlusal contacts were measured using the T-Scan III, demonstrating its utility in pediatric dental practice for assessing occlusal dynamics and treatment outcomes. [6-9].

➢ *In Implantology*

Implant dentistry is distinguished by its longevity, high patient satisfaction, predictable results, and minimal impact on surrounding tissues, making dental implant restoration a preferred solution for replacing missing teeth, particularly in cases involving free-end situations. Occlusion is fundamental to masticatory function and serves as a critical determinant of the success of oral implant restorations, a factor that can be precisely assessed using T-Scan technology. In their research, Wu et al. utilized the T-SCAN III scanner to gather dynamic quantitative data before and after the restoration of free-end implants, exploring the system's potential to redistribute occlusal force in such scenarios. Similarly, Ding et al. employed a computerized occlusal analysis system to examine longitudinal changes in occlusal force distribution and occlusal contact interval in posterior implant-supported single crowns. These studies highlight the effectiveness of T-SCAN technology in evaluating and optimizing occlusal dynamics in implant dentistry, thereby contributing to improved treatment outcomes and long-term success. [5-9].

➢ *Temporomandibular Joint Disorders (TMD)*

In the domain of temporomandibular joint disorders (TMD), factors such as Chronic Disclusion Time, occlusal interferences, and occlusal surface friction can contribute to the symptoms experienced by individuals with hyperactive masticatory muscles.

While occlusion is widely believed to play a role in the onset of TMD, conclusive evidence supporting this notion is still lacking, leading to ongoing debate within the field. However, utilizing the T-Scan method can potentially reduce the time spent in diagnosing and managing TMDs. The T-Scan technology offers valuable insights into functional occlusion, allowing clinicians to objectively assess occlusal

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contacts during continuous mandibular movement. The initial release of the T-scan I technology in 1984 paved the way for research demonstrating dental occlusion as a contributing factor to TMD. Subsequently, new parameters were developed to assess prolonged excursive movement durations, enabling more comprehensive evaluations of occlusal function. Studies, such as those conducted by Thumati et al. and Dzingute et al., utilized the T-Scan system to assess the impact of occlusal equilibration on subjective myofascial pain symptoms and to investigate the relationship between static occlusion factors and TMD, respectively. These studies demonstrate the utility of T-Scan technology in elucidating the complexities of TMD and guiding effective treatment approaches. [10].

- *In periodontics*

In periodontics, the periodontium's ability to withstand the pressure exerted by occlusal contact is crucial. Changes in tooth occlusion, often caused by early interactions or interferences, can significantly impact the periodontium. The occurrence, intensity, duration, and direction of occlusal forces all influence the periodontal tissues. The occlusal status of an individual is primarily characterized by two main features: intra-architectural relationship and inter-architectural relationship. Studies conducted by Deepika et al. explored whether periodontal therapy necessitates occlusal modification, concluding that the T-scan approach is a suitable method for assessing occlusal contacts during maximal intercuspation. Saravanan investigated the effects of increased occlusal force on the severity of periodontal disease and the impact of occlusal correction based on T-Scan evaluation on healing after periodontal therapy. The findings indicated a significant correlation between occlusal force and periodontitis severity, with occlusal correction leading to reductions in periodontal parameters, although this correlation was not statistically significant. Furthermore, Sreelakshmi et al. utilized T-Scan III to assess how occlusal loading forces, occlusal contact variability, and their correction were managed in cases of periodontitis. These studies underscore the valuable role of T-Scan technology in evaluating occlusal dynamics and guiding treatment strategies in periodontics. [2-5].

VI. ADVANTAGES

Incorporating T-Scan technology into dental practice offers multifaceted advantages. It effectively prevents occlusal interferences and premature contacts, thereby minimizing risks such as implant failure, ceramic fractures, and dental damage. Moreover, T-Scan provides invaluable legal documentation of treatment outcomes and enhances patient education through visual representation of occlusal dynamics, attracting patients seeking advanced dental care and fostering better treatment compliance. Its superior diagnostic capabilities enable accurate identification of occlusal discrepancies, leading to optimized treatment plans and reduced treatment times. Ultimately, T-Scan technology elevates the quality of care by ensuring long-term treatment success and enhancing patient comfort and satisfaction through precise occlusal adjustments.[9].

VII. LIMITATIONS

Limitations of the T-Scan System include the relatively thicker occlusal registration materials compared to thinner alternatives like articulating silk, potentially affecting functional occlusion and altering masticatory muscle functioning. Additionally, all occlusal registration items have the potential to modify occlusion, and clinicians should exercise caution when making functional occlusion changes. The sensors may be susceptible to damage when stresses are concentrated in specific regions, leading to potential errors in recording occlusal contacts or artifacts in generated images. Notably, the T-Scan device is limited to detecting occlusal interferences with dimensions greater than 0.6mm, and its two distinct modes may yield varying occlusal contact data, introducing variability in interpretation. [8].

VIII. CONCLUSION

In summary, the integration of advanced technology into dentistry has revolutionized the way we understand and manage occlusion. The T-Scan system stands out as a user-friendly and effective tool, offering dynamic occlusal assessment and precise force analysis across various tooth contact points. Its capability for permanent documentation and post-treatment monitoring further enhances its value in clinical practice. By leveraging the T-Scan system, dental professionals can achieve greater diagnostic accuracy, refine treatment strategies, and ultimately deliver improved patient care. This technology represents a significant advancement in the field of dentistry, empowering practitioners to optimize occlusal outcomes and enhance overall treatment efficacy for their patients.

Conflict of Interest: Authors declare no conflict of interest.

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