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Digital Occlusion Analysis after Orthodontic Treatment: Capabilities of the Intraoral Scanner and T-Scan Novus System

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Abstract: Digital technology is becoming increasingly popular in dentistry. The aim of this article is to demonstrate and compare the capabilities of two different digital approaches, namely, intraoral scanning and digital examination of occlusion, in the final analysis of occlusion after orthodontic treatment. The capabilities and limitations of both systems are emphasized to help clinicians determine which system to use in specific cases. Materials and methods: The study included 32 patients (15 males and 17 females) in the retention phase after orthodontic treatment. Patients were aged 15 to 28 years with a mean age of 18.62 years (±4.17), and 62.2% were aged under 18 years. At the beginning of the orthodontic treatment, 18 patients had Angle Class I and 14 had Angle Class II. Overall, 18 patients were treated without extractions and 14 with extractions, while 12 had impacted teeth. All patients wore an Essix retainer in the upper jaw and a fixed canine-to-canine retainer in the lower jaw. Intraoral scanning was performed using Trios color (3Shape, Copenhagen, Denmark, 2014), and digital occlusion imaging was performed using T-Scan Novus (Tekscan, Norwood, MA, USA, 2018). SPSS 23.0 was used to perform descriptive statistical analysis. Result and Conclusion: With the 3Shape system, the contacts are marked based on the proximity between dentitions. The T-Scan system measures the strength of the contacts, regardless of their area. Despite its many advantages, intraoral scanning is not a reliable method for recording occlusions. The results obtained are not incorrect, but they include limited parameters for analysis. The T-Scan system provides comprehensive results and allows analysis and treatment of occlusal dysfunctions. The T-Scan system can provide information on the first contact, strength of the contacts, contact distribution on each tooth, sequence of contacts, maximum bite force and maximum intercuspation, path of the lower jaw movement, and occlusion and disocclusion times as well as record videos with active sequences and distributions of the contacts. There is a good collaboration between intraoral scanning and digital occlusion determination.

Keywords: dentistry; digital impression; digital occlusion; intraoral scanning; 3Shape; T-Scan Novus; orthodontics

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1. Introduction

Digital technology in dentistry is undergoing rapid development. Digital dental impressions made by intraoral scanners have many different applications and advantages over classic impressions, especially during the pandemic. These advantages include a lack of contact with the mucosa, comfort due to the lack of impression material, immediate visualization on the screen with the possibility of inspection and correction, real-time visualization, less time consumption, and easy and selective repeatability [1]. In contrast, conventional impressions require dentists to make a tray selection, perform an impression using different materials and methods depending on the specific case, disinfect the impression, ship it to the laboratory, pour the impression, and ultimately create a master model. The digital impression procedure has fewer steps, which includes software setup, scanning, digital shipping to the laboratory, and creating a digital master model [2]. Accuracy can be affected by various factors, such as operational and clinical differences (e.g., need for coating, larger scanner head, and specific distance from the target; absence of in-office milling units; difficulty in detecting deep margin lines in prepared teeth and/or in case of bleeding; and need for a learning curve) and cost (e.g., purchase and management costs) [3,4]. Accuracy is the consolidation of two elements, both essential and complementary: “trueness” and “precision.” The term “trueness” refers to the ability of a measurement to match the actual value of the quantity being measured. Precision is defined as the ability of a measurement to be consistently repeated or, simply put, the ability of the scanner to produce repeatable results when applied in varied measurements of the same object [5].

Intraoral digital impression techniques can be discussed in terms of different dimensions, including the categories and principles of currently available intraoral digital impression apparatus; their operating characteristics; and a comparison of the operation, accuracy, and repeatability of intraoral digital impressions and conventional impressions [6]. Dental arches typically have different widths depending on personality traits (e.g., small, elongated, square, or narrow face; large, medium, or small head size, etc.) or age (child or adult), which can affect the precision of some intraoral scanners during the scanning of the whole jaws [7]. The scanning area and scanning accuracy are influenced by the type of intraoral scanner, scanning distance, and scanning angle selected to acquire the digital scans [8]. A new option is optical jaw-tracking systems, which can record mandibular motion during various treatment phases. The process allows occlusal adjustments using the patient’s mandibular motion and facilitates the prosthetic design process, thus minimizing chair time at delivery [9]. This technique of optical jaw tracking for digital recording of the maxillomandibular relationship can visualize the maximum intercuspation and centric occlusion [10]. In a comparative research, Revilla-León et al. measured the accuracy (trueness and precision) of the maxillomandibular relationship at the centric relation position recorded using three different intraoral scanners with or without an optical jaw tracking system. Except for one intraoral scanner system, the optical jaw tracking system improved the trueness value [11]. An additional new software application can directly combine and merge three-dimensional cone beam computed tomography (CBCT) and electronic jaw motion tracking (JMT) information. This examination can improve the treatment of bruxism and temporomandibular disorders (TMD) [12].

Orthodontic treatment is aimed at improving not only the aesthetics but also the function. Achieving a balanced occlusion with uniform contacts without blockages is necessary to attain normal masticatory function and muscle balance [13,14]. Andrew’s six keys to occlusion, which include molar relationship, crown angulation, crown inclination, no rotation, no spaces, and flat occlusal planes, are utilized in orthodontics [15]. A retention phase is usually necessary after active orthodontic tooth movement to maintain teeth in a new ideal esthetic and functional relationship and prevent their inherent tendency to return to their previous position [16]. Bonded or removable retainer can be used in the retention phase [17]. Fixed and removable retainers show similar effectiveness in maintaining stability outcomes [18]. The number of follow-up visits during the retention phase is affected by the practitioner’s experience, whether vacuum-formed retainers were used, whether the orthodontist considered the presence of third molars or special-need patients when choosing the type of retainer, and to whom the orthodontist attributed responsibility during the retention phase [19].

Several occlusal analyzers are available for registering the occlusal relationships between dental arches. These indicators can be categorized into qualitative and quantitative indicators, with quantitative indicators being capable of measuring tooth contact events. Qualitative indicators include articulating paper, film and silk, occlusal spray, metallic shim stock film, and high spot indicator. In contrast, quantitative indicators include the T-Scan occlusal analysis system and virtual dental patient [20,21]. Articulation paper is the most accessible means of inspecting and visualizing occlusal contacts. However, it carries a risk of error as extensive plane contact is not always strong, with single-point contacts being more powerful [22]. T-Scan Novus is an objective analysis tool that can determine both the force and timing, making it superior to articulating paper, which can only determine the location [23]. The T-Scan occlusal analysis system records and analyzes bite force distribution, indicating its relative intensity and occlusal timing. The balance plot, time display, and comparison screen are the three ways in which occlusal contacts can be recorded and analyzed [24,25].

T-Scan 10 (2018), the newest version of the T-Scan system, has improved software details that benefit implant treatment. The previous version had artifacts in the frontal area, but T-Scan 10 can remove sensor artifacts due to overlapping front teeth. The software features of T-Scan 10 include analyzing occlusal function and an implant warning tool. Digital models can easily be uploaded, and T-Scan data can be overlayed onto an STL digital arch scan [26].

In one comparative study, three different techniques (intraoral and laboratory scanners, T-Scan III system, and the conventional classical method with articulating paper) were compared, and intraoral scanners showed reliability in occlusion registration when compared to the current gold standard [27]. In clinical demonstrations, intraoral scanning ends with an occlusion scan (bite registration). The accuracy of scanners differs depending on the correct scanning technique (every brand has a scheme and consequence of scanning steps) and the number of images (a large number of images can make the file heavy). Digital T-Scan analysis provides details of occlusion evolution, such as a digital timeline, contact sequence, intensity, and type of contacts between the left and right sides at every moment as a video recording as well as parameters such as occlusion and disocclusion times, which are very important in bruxism treatment [28,29]. In a comparative survey, the highest occlusal contact area values were detected using the T-Scan and the lowest using the 3D surface scan [30].

Digital technologies play a part in teledentistry. A digital impression is an initial unit of the whole process [31]. It allows minimal patient contact with the treating dentist. Dental technicians do not have any contact with saliva or blood from the patient, which can be potentially dangerous [32]. Telemedicine clinics and health phone applications were very popular during the COVID-19 pandemic and continue to develop. In awake bruxism, it is possible to identify 70% of symptoms through the different frequencies of behavior provided by the app [33,34]. T-Scan computerized occlusal analysis technology eliminates the process of subjective interpretation of occlusal contacts obtained using articulating paper marks, precisely pinpoints the excessively forceful contact locations, and displays them for analysis of the occlusal force distribution [35]. Among the dynamic occlusal parameters (occlusion and disocclusion times) evaluated, centric slide and balancing side interferences have been found to be highly influential in the etiology of temporomandibular disorders (TMD) [36]. Some general diseases, such as multiple sclerosis and osteoarthritis, can affect the evolution of TMDs [37,38].

This article aims to demonstrate the capabilities of two different digital approaches, namely, intraoral scanning and digital examination of occlusion with T-Scan Novus system, in the final analysis of occlusion after orthodontic treatment. The capabilities and limitations of both systems are emphasized so that clinicians can easily be guided on which system to use in different cases.

2. Materials and Methods

A total of 32 subjects (15 men and 17 women) who were in the retention phase after completing orthodontic treatment were included in the study. Patients were aged 15 to 28 years with a mean age of 18.62 (±4.17), and 62.2% were aged under 18 years. At the beginning of their orthodontic treatment, 18 patients had an intermaxillary relation in the canine's zone Angle Class I, while 14 had Angle Class II. A total of 18 patients underwent treatment without extractions and 14 underwent treatment with extractions, while 12 had impacted teeth, as shown in Table 1. The average age was 17.34 (±3.71) for men and 19.12 (±6.02) for women. The average duration of treatment was 27.68 months (±6.46) for men and 29.12 (±2.98) for women. All patients wore an Essix retainer on the upper dental arch and a fixed canine-to-canine retainer on the lower dental arch.

Table 1. Distribution of patients according to Angle class, extractions, and impacted teeth.

		Extractions		**Impacted Teeth**	
		No	**Yes**	**No**	**Yes**
Angel_class	Angle Class I	12	6	12	6
	Angle Class II	6	8	8	6
Total		18	14	20	12

The norm for completion of orthodontic treatment, regardless of whether it involves extraction or not, is the achievement of an orthognathic bite, coincidence of the midlines of the upper and lower jaw, multiple contacts, and Angle Class I. This was also the reason for conducting the study on orthodontically treated patients with balanced occlusion. The presented methodology can be used in many cases, such as to detect traumatic areas after prosthetic treatment, implant placement, bruxism patients with the help of occlusion and disocclusion time values, temporomandibular joint (TMJ) disorders, asymmetrical lower jaw movement due to blockage, etc. [20,24,30].

Intraoral scanning was performed using Trios Standard Pod (3Shape, Copenhagen, Denmark, 2014). The workflow included scanning the upper and lower dental arches and the right and left bites. The information was formatted and saved as an STL file using the specialized 3Shape Unite (2021) software. The same clinician performed the scans with the two devices.

For more precise analysis, digital imaging of the occlusion relationship was performed using T-Scan Novus (Tekscan, Norwood, United States, 2018). The system comprises of a sensor, sensor frame, handle, cable, and system unit. The pressure-sensitive sensor is placed in a holder (frame) towards the device and is positioned between the dental arches. The patient is in an upright position with the back of the dental chair at the maximum straight position, and the head is straight without touching the headrest. The proper technique requires the position of the holder being parallel to the floor. The pin of the sensor frame is situated between the upper central incisors. The patient closes their mouth to ensure complete contact (Figure 1). For better visualization, intraoral scans were preimported. Without intraoral scans, the first step before digital measurement of the occlusion is to measure and fill the frontal teeth's mesiodistal size and add information about the dental status (especially missing teeth). The clinician needs articulation paper to find the corresponding contact of the digital image. Preimportation of the intraoral scans shortens the clinical time. Here, contact points are positioned on the tooth surfaces of the screen image and can easily be found in the patient's mouth. Licensed software version 10.0.40 (T-Scan 10, Tekscan, 2022) was used.

Before starting the examination, both digital systems require the entry of dental status, which minimizes contact misplacement. Importing a scan from one system to the other also reduces the potential for error.

The statistical package SPSS version 23.0 was used to perform statistical computations. The patients' demographic characteristics were analyzed using descriptive statistics. Counts and percentages were used for categorical variables. The mean and standard deviation were used for the occlusal force percentage of the four zones of first contact. Microsoft Office 2016 was used for tables and figures.

Figure 1. Positioning the T-Scan device in the patient's mouth.

3. Results

Based on intraoral imaging and occlusion scans (right and left), the 3Shape software generates a color map of the occlusal contacts. Therefore, it is necessary to ensure that the patient does not relax their lower jaw during the occlusion scan. The areas marked in red on the map are the densest, followed by yellow areas 1 mm apart and green areas 2 mm apart. The symmetrical distribution of the contacts can be used as an indication of proper scanning of the dental arches without any deviations or unilaterally stronger contacts (Figure 2A).

The T-Scan system also produces a color map, but it is based on the pressure on the sensor and only real contacts are counted. The color marks correspond to the strength of the contacts, with strong contacts in red, followed by yellow, green, and weak contacts in blue. Pressure information on each tooth is automatically outputted by the quadrants (frontal right and left, distal right and left). Preliminary importing of the digital impressions allows the software to place the contacts in their exact places on the tooth surfaces. Without them, it is necessary to use articulation paper to transfer information to the patient's mouth (Figure 2B).

Both digital systems can determine the occlusal contacts. This study used the same digital impressions but interpreted them with different systems. The 3Shape system marks only the densest contacts, which does not necessarily mean they are the strongest. This system visualizes based on proximity. On the other hand, the T-Scan system measures the strength of the contacts, which is easily demonstrated by bar charts of different colors. Figures 3A,B and 4A,B show the dense contacts according to 3Shape, the first contact according to T-Scan, and the strength of the contacts according to T-Scan. The following results can be seen (the pictures are examples; the patient was randomly selected, and the pictures are intended to show the differences between the two systems, not to draw conclusions):

- The tight contact of tooth 13 according to the 3Shape system is the first contact according to the T-Scan system;
- The tight contact of tooth 14 according to the 3Shape system is moderately strong (light blue marking) according to the T-Scan system;
- The tight contact of tooth 15 according to the 3Shape system is the strongest (yellow marking) according to the T-Scan system;

- The tight contacts of teeth 26 and 27 according to the 3Shape system are moderately strong (green marking) according to the T-Scan system;
- All contacts in the 3Shape system have the same markings, but the difference between them can be analyzed only by the T-Scan system;
- The percentage distribution of the strength of the contacts in the dental arch on the single teeth or on the quadrants can be visualized only by the T-Scan system;
- The T-Scan system generates a video and shows the sequence and strength of the contacts in great detail, combined with the movement of the lower jaw;
- The T-Scan system notes occlusion and disocclusion times, which are important parameters in the examination and treatment of patients with parafunction;
- The movement of the lower jaw and its direction and shape can also be documented only through the T-Scan system.

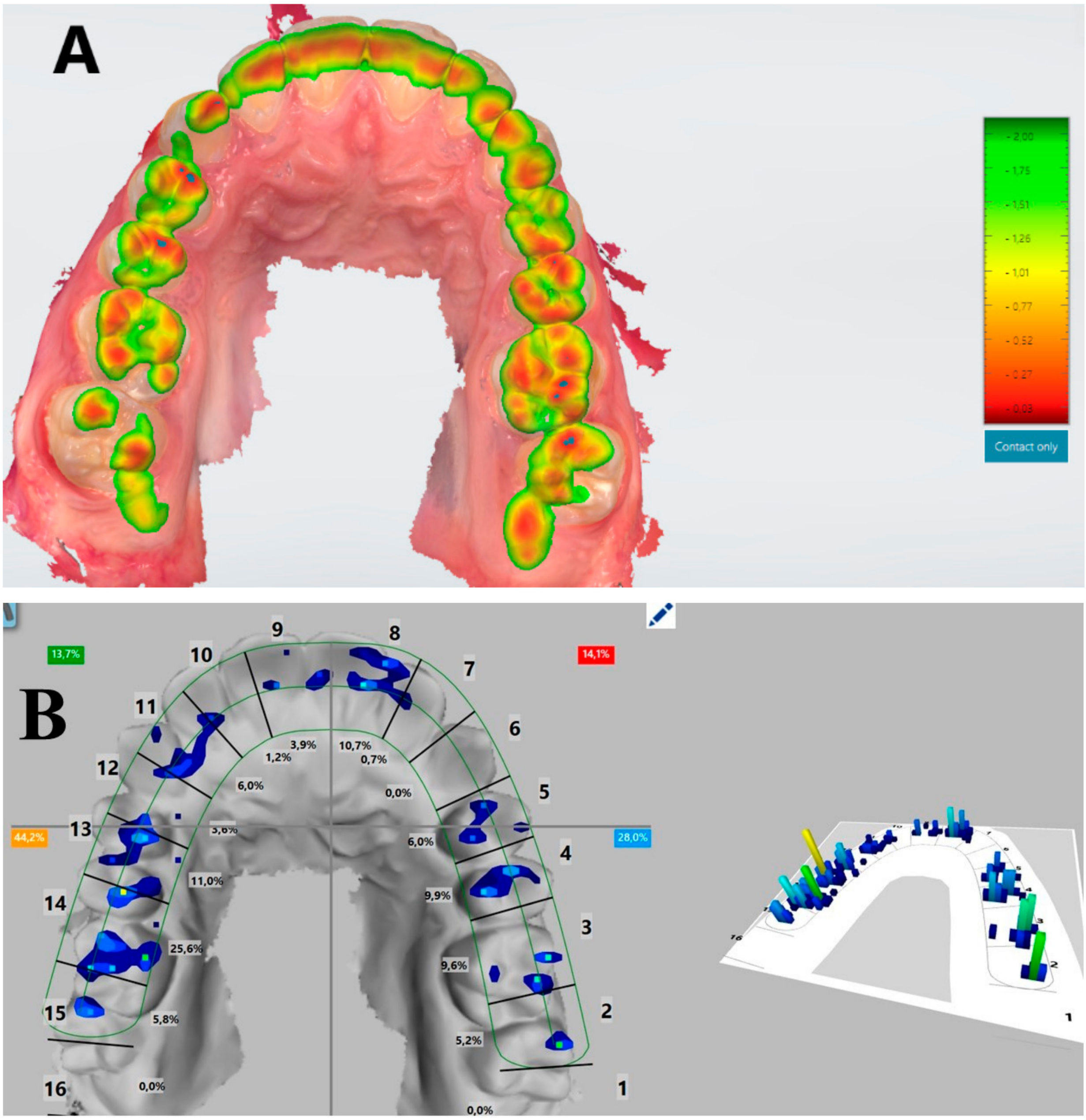

Figure 2. (**A**) Occlusion map from intraoral scanner Trios (3Shape, 2014); (**B**) occlusion map from T-Scan Novus (Tekscan, 2018).

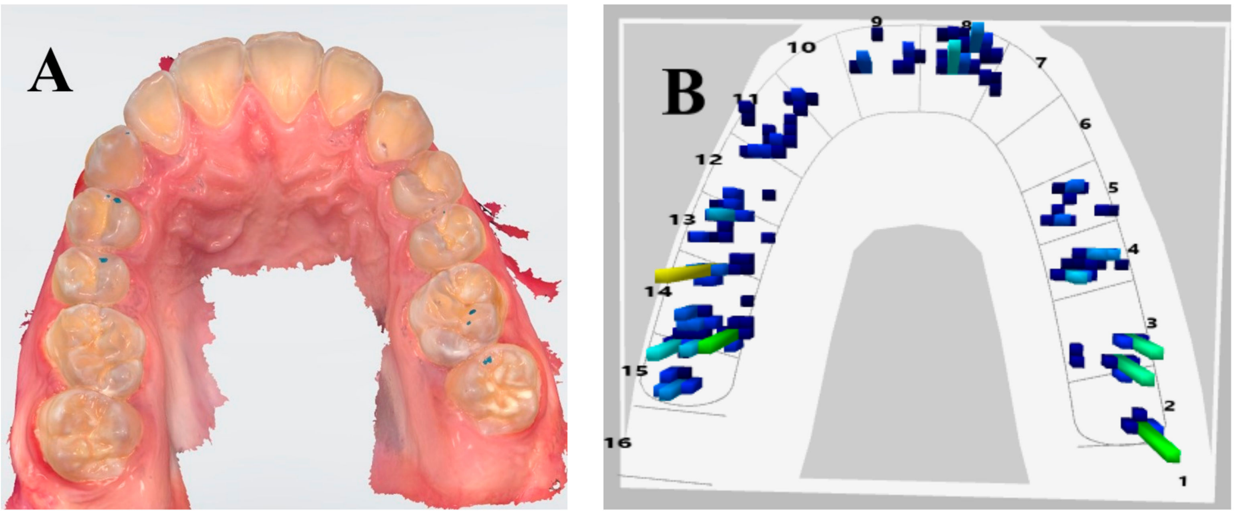

Figure 3. (**A**) Complete contacts according to the Trios system. The system detects contacts in only four points: the mesial surface of the first upper right premolar, the mesial surface of the second upper right premolar, the central area of the first upper left molar, and the mesial surface of the second upper left molar. (**B**) Occlusal diagram according to the T-Scan system. Almost symmetrical contacts exist except for the upper left lateral incisor and canine area.

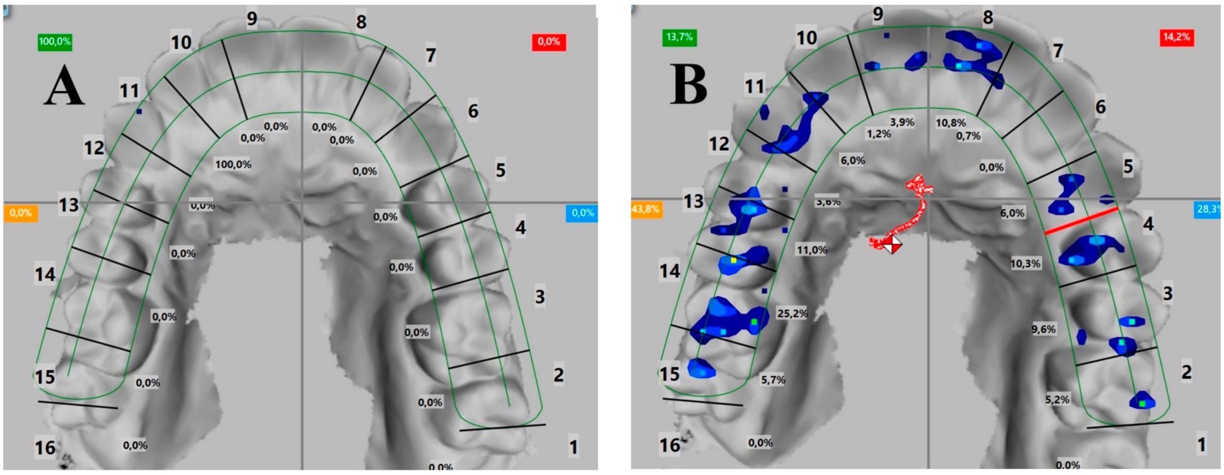

Figure 4. (**A**) First contact (T-Scan system) on the upper right canine. (**B**) Quadrant distribution and lower jaw movement (T-Scan system). The system divides the dentition into four quadrants: left and right frontal and left and right distal. The force distribution is shown on each tooth. The path of the lower jaw movement is also presented.

To better visualize the differences, the particular indicators are shown in Table 2. The purpose of the table is not to reject intraoral scanning; on the contrary, it is a necessity in modern dentistry to indicate its possibilities. For standard treatment, these possibilities are absolutely sufficient. For more specific treatment (such as bruxism and occlusion trauma), the help of the T-Scan system is needed.

The T-Scan system can only determine the first contact in central occlusion. The results are presented in Table 3. In rare cases, there may not be only one first contact. In two of our measurements, we observed a double first contact but with different pressures:

- Male, 17 years old, right frontal zone 32.6%, left distal zone 67.4%;
- Female, 26 years old, left frontal zone 41.2%, left distal zone 58.8%.

Table 2. Comparison between intraoral scanning and digital occlusion determination with the T-Scan system.

Type of System Comparative Indicator	Trios Intraoral Scan (3Shape System)	T-Scan Novus (Tekscan)
Occlusal map	Yes	Yes
Distance between the upper and lower jaws	Yes	No
Strength of the contacts	No	Yes
Contact distribution on each tooth (in%)	No	Yes
Sequence of the contacts	No	Yes
First contact	No	Yes
Maximum bite force	No	Yes
Maximum intercuspation	No	Yes
Occlusion	Virtual articulator with possible and probable movements	Video of real movements, dynamic occlusion
Scheme of lower jaw movement	No	Yes
Occlusion and disocclusion times	No	Yes

Table 3. Comparison of zones of the first contact between males and females as determined by the T-Scan system.

Zone	Male (N = 15)		Female (N = 17)	
	Mean ± SD	Number of Cases	Mean ± SD	Number of Cases
Right distal zone	46.67 ± 1.65	7	47.06 ± 1.78	8
Right frontal zone	6.67 ± 0.23	1	5.88 ± 0.34	1
Left frontal zone	6.67 ± 0.23	1	0 ± 0.12	0
Left distal zone	40.00 ± 1.52	6	47.06 ± 1.78	8

4. Discussion

The purpose of orthodontic treatment is threefold: morphological norm, optimal aesthetics, and functional balance. The study was performed on an orthodontically treated patient who achieved a balanced occlusion, meeting the orthodontic criteria for successful treatment, including overjet and overbite in norm, Angle Class I, with multiple contacts, without blockages, sprouted tubercles, and Godon's phenomenon [15]. After orthodontic treatment, the teeth in the dental arches were arranged and leveled according to rules similar to the arrangement of artificial teeth in full dentures. The strongest contacts were 2.03 ± 1.57 per denture, and in the most distal zone, the total strength in the maximum intercuspation averaged 99.39 ± 0.66% [39]. Cases of partial or complete edentulism in children are rare and are most often genetically determined. In these cases, orthodontic and prosthetic treatment is combined. The clinical protocol includes orthodontic treatment of the existing teeth, placement of fixed or removable structures, and implants after the completion of body growth (18 years of age) [40,41].

According to Trpevska et al., evidence supports the T-Scan system as a quick and precise method for identifying the distribution of tooth contacts. It can be a promising clinical diagnostic screening device for determining and improving occlusion after diverse dental treatments [42]. The different Angle classes show many nonideal occlusal function characteristics, including Class I. The apparent "ideal occlusion" does not always form an ideal occlusal function. Digital occlusal analysis using the T-Scan system helps diagnose the different variations of malocclusion [43].

Qadeer's study explored measured excursive movement occlusal contact parameters and their association with temporomandibular disorder symptoms between non- and post-orthodontic subjects. Statistically significant differences were observed, with 72.7% working and 27.3% nonworking side contacts seen in the group without orthodontic treatment. In contrast, in the group after orthodontic treatment, near-equal 54.7% working and 45.3% nonworking side contacts were seen. Canine guidance was observed in 60% of the nontreated group and 24% in the post-treated group. TMD symptoms were most commonly presented (72%) among patients after orthodontics. The digital occlusal analysis is a neutral diagnostic method that identifies the location and balance of lower jaw movements after orthodontic treatment [44]. According to Thumati, the T-Scan system can be used in a treatment protocol [45].

Some anatomical features can influence precision. The different widths of dental arches can affect the accuracy of scans. In a clinical trial with Trios scanners (3Shape), no significant differences were found between width and accuracy. The scanning technique is more important than the shape and length [7]. According to a literature review by Morsy et al., virtual interocclusal records with intraoral scanners presented acceptable results for diagnostic precision, with sensitivity of 0.76, specificity of 0.80, diagnostic odds ratios of 14.77, area under the summary receiver operator characteristic of 0.87, cut-off point of 80, positive likelihood ratio of 3.66, and negative likelihood ratio of 0.31. The pooled data for trueness and precision were within acceptable limits. The studies included in the review reported accurate occlusion for fixed restorations fabricated using virtual interocclusal records with intraoral scanners. Furthermore, most of the research on trueness based on virtual occlusal contact zone reported acceptable accuracy [46]. Together with other technologies and computerized devices, intraoral scanning represents one of the most important instruments introduced in dental clinical practice, and future studies are needed in order to understand the possibilities and limitations of these new technologies [47,48].

An alternative to intraoral is extraoral scanning. They are usually applied in cases where the clinician does not have an intraoral scanner available or prefers to work with conventional impression methods. An extraoral scan is a laboratory scan of an impression or plaster cast. Precision of extraoral scanning is acceptable in scanning any scope of arch region [49]. In a comparative study, the extraoral scanners showed substantially higher precision measurements for cross-arch measurement. Surface topography did not correlate to precision; rather, precision correlated with the scanning mechanism. For quadrant scanning, both intraoral and extraoral scanners are recommended, but extraoral scanners are recommended for full-arch scanning [50].

The accuracy and reproducibility of occlusal marking through the T-Scan system are still uncertain. A preliminary study was conducted on four specific points loaded on a sensor by applying weights from 0.1 to 10 kg. The results showed that certain insensitive zones were caused by anatomical features, the most sensitive area was measured from 0.1 to 2.1 kg, and the device was more suitable for recording within lower loads. Although the system has certain shortcomings in terms of reproducibility, it contributes to achieving diagnosis and treatment of occlusal contacts for quantitative estimation [25]. T-Scan can be used in the case completion process. After the orthodontic appliance is removed, changes in occlusion result from “settling” because teeth can move freely in the periodontium. Despite subsequent treatment, a visually “perfect” Angle Class I relationship and ideal occlusal contacts are often not the result of tooth movement alone. Creating simultaneous and uniform contacts after the removal of a fixed appliance can be achieved using T-Scan data to optimize the final occlusal contact pattern. The software’s force distribution and timing indicators (the two- and three-dimensional force views, percentage of force per tooth, per quadrant, per half-arch, the center of force, and the occlusion and disocclusion time) help obtain an ideal occlusal force distribution during the completion of the case [51,52].

Through a virtual procedure, the T-Scan system detects occlusal contacts and intraoral scanners obtain the occlusal surfaces. After aligning the three-dimensional occlusal surface and the T-Scan registration, the resulting contacts are projected onto the patient’s occlusal surfaces, producing occlusal forces over time. The results received with this procedure demonstrate the relevance of integrating different tools and software and the complete integration of this procedure into a dental digital workflow [25].

Classical occlusal analysis using articulation paper only provides some necessary information to achieve balanced occlusal contacts. Intraoral scanners, on the other hand, can provide similar information for clinical examinations. Due to the possibility of multiple magnifications and views from different angles (including from inside the mouth and the throat), the analysis is much more accurate and thorough. Digital T-Scan analysis can also provide additional valuable information, including force intensity, the moment of first contact, and localization of severe traumatic contact, which can be used for analysis and treatment [28,29]. According to Fraile et al., intraoral scanners appear reliable in intermaxillary occlusal contact registration compared to intra- and extraoral digital scanners and T-Scan III system [27].

Other studies comparing intraoral scanning and T-Scan in natural dentition confirm our results. Their conclusion is that T-Scan is a reliable method for measuring occlusal contact area but 3D surface scans are not. Occlusal registration shows high validity [29].

Intraoral scanning can be a great method of checking occlusion in general. The T-Scan methodology is only aimed at determining occlusion. In addition to diagnostics, it can also be used for treatment by establishing preliminary contacts and overloading certain areas, which is especially important in the integration of implants, treatment of bruxism, and TMJ diseases [53–55].

Research Limitation

The limitations of the present study included the sample size of 32 patients, all of whom were treated with the straight wire technique (MBT system). The patients wore an upper Essix retainer and a fixed lower canine-to-canine retainer.

Operator experience appears to be an important factor in the overall evaluation of intraoral scanners [56]. One possible limitation for intraoral scans can be the size of the scanner head. Due to the conical shape of the head, it may be difficult to reach the posterior molar areas in adolescents with a small oral cavity [57]. Most of the existing limitations can be overcome with experience and good clinical skills. However, higher-quality studies are essential for orthodontists to properly interpret data, evaluate new findings, compare the results to existing evidence, and form an up-to-date and objective opinion [58].

Another limitation is the technical characteristics of the T-Scan device. It has been shown that thinner occlusal registration materials provide more consistent records of contact points. T-Scan sensors are made as thin as possible (0.1 mm) to meet technological demands, but they are still relatively thicker than occlusal indicators such as articulating silk. The sensors can be damaged when forces are concentrated over a small area, such as a sharp tooth cusp. The T-Scan system can reproduce occlusal interferences only exceeding 0.6 mm in dimension [59].

5. Conclusions

The 3Shape system marks contacts based on proximity between dentitions, while the T-Scan system measures the strength of contacts regardless of their area. Despite its many advantages, intraoral scanning is unreliable for recording occlusion. Although the results obtained are correct, they include limited parameters for analysis. In contrast, the T-Scan system provides comprehensive results and allows the analysis and treatment of occlusal dysfunctions. The T-Scan system can provide information about the first contact, strength of contacts, contact distribution on each tooth, sequence of contacts, maximum bite force and maximum intercuspation, scheme of the lower jaw movement, and occlusion and disocclusion times. There is a good collaboration between intraoral scanning and digital occlusion determination.

The research team's future plans include deepening and covering other perspectives in the study of the two digital systems.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Medical University of Plovdiv, Bulgaria, protocol №3/20.05.2021.

Informed Consent Statement: Informed consent was obtained from all patients involved in the study. Written informed consent was obtained from the patients to publish this paper.

Data Availability Statement: Intraoral scanning were conducted at the CAD/CAM Center Dental Medicine at the Research Institute, Medical University of Plovdiv, Bulgaria.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

TMJ	temporomandibular joint
TMD	temporomandibular disorders
MBT system	McLaughlin, Bennett, Trevisi (by the names of the creators)
CBCT	cone beam computed tomography
JMT	jaw motion tracking

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