"Evaluation of Occlusal Bite Force Distribution by T-Scan in Orthodontic Patients with Different Occlusal Characteristics: A cross Sectional Observational Study"

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Research Article

Keywords: "Occlusal Bite", "Force Distribution", "T-Scan", "Orthodontic Patients"

Posted Date: February 16th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2527899/v1

Abstract

Background

The aim of Orthodontic treatment apart from esthetic and functional corrections is uniform force distribution. Hence Occlusal analysis using a T scan gives scope for a precisely targeted treatment plan. The T-scan evaluation of occlusal force, time, and location of contacts from initial occlusal contact to maximum intercuspation enable the orthodontist to sequentially balance the occlusal forces on right and left side by specific treatment plan options.

Objective

The current study aimed to determine the force distribution by using T-Scan as well as the NET discrepancies of forces generated at a maximum intercuspation position in the first molar region between the left and right sides of the mouth.

Methods

This is a descriptive-correlational study that was carried out in Ras Al Khaimah College of Dental Sciences clinics and Ajman University clinics from January 2020 to September 2022 by using the convenience sampling technique.

Results

The present study consisted of 158 participants. Analysis of Variance (ANOVA) showed that there is a statistically significant difference in percentage of force between the three types of malocclusions (I, II, and III) on the right molar side (B-16 and B-46) ($p < 0.05$). Moreover, the overall discrepancy showed a statistically significant difference in the three types of malocclusion classifications ($p < 0.05$). On the other hand, there was no statistically significant difference in the percentage of force between B-26 and B-36 ($p > 0.05$). Post hoc showed a statistically significant difference in percentage of force between Malocclusion Class I and Class III on the right molar with a mean difference of 4.11190 ($p < 0.05$). Similarly, there was a statistically significant difference in B-46 between Malocclusion Classes I and II, 4.01806 ($p < 0.05$). Additionally, post hoc showed a statistically significant difference between Malocclusion Class I and Class III with a mean difference of -4.79841 ($p < 0.05$) on the right molar.

Conclusion

The T-Scan is a useful tool for assessing occlusal discrepancies and can be helpful during treatment planning and follow-up, especially for orthognathic surgery patients. T-scan could be used in orthodontic

therapy in a simple and efficient way. Also, it turned out to be a useful tool for diagnosing problems and gave us new information about how therapies work. In this study, T-Scan showed that it can measure occlusal forces in timing in an objective, accurate, and repeated manner. The current study found that T-Scan was better able to report the difference in the percentage of force on the right molar side than on the left side.

Introduction

The contact between the upper and lower dentition while the teeth are in maximum intercuspation is defined as dental occlusion [1]. Furthermore, the phrase "dynamic occlusion" refers to tooth interactions that occur during mandibular movements [2]. Because the number, location, and position of the teeth vary so significantly, the conceivable combinations of distinct forms of dental occlusion are enormous. As a result, numerous traits have been classified to describe categories of malocclusions in order to investigate dental occlusion. Angle's classification, which differentiates distinct types of dental occlusion based on the sagittal relationship between the upper and lower teeth in orthodontic patients is a widely used classification [3]. The orthodontic therapeutic goal is to achieve an ideal alignment of teeth in the dental arch embracing static occlusion that permits an even distribution of the generated forces during mastication. For instance, any premature occlusal contacts can generate occlusal stress which leads to alterations in the tooth-supporting tissues, the masticatory muscles, and the temporomandibular joint [4].

Following orthodontic treatment, the retention phase is designed to keep the corrected occlusion and function. Without retention, recurrence or an adverse change from the ultimate occlusion is expected [5]. Stabilization is a positive improvement that occurs following orthodontic treatment. Teeth will naturally erupt toward one other in search of stable sites of contact, enhancing intercuspation and masticatory performance. The number of occlusal contacts rises with settling [6]. Since the introduction of modern orthodontics, dental occlusion and occlusal pressures have been proposed as one element for stability [7].

The T-Scan is an objective approach for assessing dynamic dental occlusion. It enables computerized analysis, which eliminates operator subjective paper mark misperceptions; additionally, T-Scan measurements are unaffected by saliva [8]. T-Scan is a digital occlusion analysis device that uses a small, flexible, pressure-sensitive bite transducer inserted in a dental arch-shaped recording sensor to record and evaluate tooth contact, force, and timing in real-time [9]. T-Scan occlusal data can be graphically displayed for study in two or three dimensions (Fig. 1). The recorded occlusal data can be used to calculate the occlusal force distribution, occlusal interference, and relative force of each interference. The T-Scan records patient parameters such as the center of force, confirming the occlusal force's symmetry. It can determine the first contact between maxillary and mandibular teeth, the maximum biting force, the maximum intercuspation, and the occlusal position of the mandible in which the cusps of the maxillary teeth fully interpose with the cusps of the opposing arch. Maximum intercuspation is a crucial jaw position that defines the mandibular and maxillary anterior-posterior and lateral relationships, as well as the superior-inferior relationship known as the vertical dimension of occlusion. When evaluating an orthodontic patient, maximum intercuspation is critical [8]. By translating qualitative data into quantitative parameters, the T-scan 10 system provides a precise means of assessing the sequence of time and occlusal contact force magnitude. By displaying it on a digital display, it also boosts the patient's confidence [10].

In our study, the T-scan III Novus was used to record multi-bite scans for multiple patients. T-scan was used to study different types of malocclusions; Angle's Class 1 malocclusion, Angle's Class II malocclusion, Angle's Class III malocclusion, and normal occlusion. To the best of the authors' knowledge, there are no studies investigating the occlusal bite force distribution by T-Scan in orthodontic patients with different occlusal characteristics in the United Arab Emirates. As a result, the primary goal of this study was to determine the NET discrepancies of forces generated at a maximum intercuspation position in the first molar region between the left and right sides of the mouth.

Methodology

Design, setting, and sampling.

This is a descriptive-correlational study that was carried out in Ras Al Khaimah College of Dental Sciences clinics and Ajman University clinics from January 2020 to September 2022 by using the convenience sampling technique. This strategy is the most common type of non-probability sampling, which focuses on gaining information from participants (the sample) who are 'convenient' for the researcher to access and meet the inclusion criteria.

Inclusion And Exclusion Criteria

Participants diagnosed according to Angle's classification of malocclusion with Class I malocclusion, Class II malocclusion, Class III malocclusion, or no malocclusion (normal occlusion) were included in the present study. In the inclusion criteria, only malocclusions that had not undergone any orthodontic procedures and had a full complement of permanent teeth (excluding third molars) were included. On the other hand, participants with TMJ disorders and patients with other systemic, congenital, and traumatic disorders affecting the jaw, chronic periodontal disease, and any missing tooth apart from third molars were excluded from this study.

Sample Size

To achieve a power of 0.80, an a priori power analysis was performed by using the G*Power3 software, with the alpha level set to 0.05 and the medium effect size ($d = 0.30$). [11]. Therefore, the estimated sample size of 128 patients has an 80% probability of detecting a true difference (of medium effect size) between the four groups when the significance level is set at $p < 0.05$.

Study Procedure

The research was reviewed and approved by the Research Ethics Committee (Ref# D-H-F-11-Nov). Patients seeking orthodontic treatment at Ras Al Khaimah College of Dental Sciences and Ajman University Clinics were asked to voluntarily participate in this study. The study protocol was explained to each potential subject, and signed consent was obtained for those who agreed to participate and fulfilled the following inclusion criteria: complete permanent teeth excluding the third molars, normal temporomandibular joint function, and absence of periodontal pathology. Patients were invited to be seated on the dental chair with the lower and upper parts of their body positioned at an angle of 90o.

The procedure was carried out by using the T-Scan III NOVUS device that consists of a sensor film registering occlusal contacts, a data transferring module linked the sensor to a computer called the 'handpiece'. A software program collected the gathered data and transfers it to the computer enabling visualizing the captured data in 2 and 3-D formats on the monitor. The recording sensor is inserted intraorally between the dental arches so that the central mark is positioned between the central incisors of the patient. Recording starts with pressing the button on the handlebar; the patient is instructed to occlude firmly to complete intercuspation. A multi-bite type scan was recorded for each subject consisting of 3 bites consequently after each other to minimize patient error. One of the key features provided by the T-SCAN software is a force vs time graph. On each graph deduced, 4 dimensions are written by the software. These dimensions are marked by points on the graph. Points A, B, C, & D (Fig. 2). Point A represents the first contact point that occurs upon occluding. Point B represents the maximum intercuspation position (MIP) when the patient is in 100% full occlusion. Point C symbolizes the first disclosure between the teeth that occurs upon releasing the occlusion load. Finally, point D represents full disclosure where no teeth are expected to be in contact. (Fig. 3).

The average value in these 3 bites was the readings taken into consideration in this study. The B point interval which represents the MIP (Maximum intercuspal position) was the dimension of interest in this study. Another method of data provided by the software is the occlusal load percentage bared by each tooth alone. This is given in either a 2D image or a 3D image according to preference.

After extracting the reports for all studied specimens from the software, the average bilateral occlusal load was calculated for each specimen in each class by adding all occlusal forces on the right side and left side of the jaws. The net discrepancies were deduced by subtracting those two numbers to find the differences in the forces distributed along both sides of the jaws. Furthermore, to find the total average occlusal force of the first molar in each class in MIP, the values of the four first molars in each specimen were compacted into one value which was the average of the four molars altogether. From that value, the classes were compared with each other using multiple statistical tests.

Statistical analysis

The statistical analysis was conducted using the Statistical Package for Social Sciences version 26 (SPSS; IBM Corporation, Armonk, NY, USA). The Shapiro-Wilk test indicated that the data were approximately normally distributed. ANOVA was performed to evaluate the association between three types of teeth classification. Post hoc multiple comparisons were performed using the Tukey-HSD method to detect significant intergroup differences. The significance level was set at $p < 0.05$.

Results

The present study consisted of 158 participants. The majority were males 99 (62.7%) and females 59 (37.3%). In terms of nationality, 90 (57%) were UAE citizens, followed by Indians 27 (17.1%), Pakistanis 18 (11.4%), and 23 (14.6%) from different nationalities. The data was collected from two universities, 85 (53.8%) from Ras Al Khaimah College of Dental Sciences 73 (46.2%) and from Ajman University. In regard to the malocclusion classification, 84 (53.2%) had Class I Malocclusion, while 32 (20.3%) had Class II Malocclusion and 42 (26.6%) had Class III Malocclusion. The mean age of participants was 28.27 ± 11.31. (Table 1).

Table 1
Characteristics of participants

Variable	Group	Frequency	Percentage
Gender	Males	99	62.7
	Females	59	37.3
Nationality	UAE Citizen	90	57.0
	Pakistani	18	11.4
	Indian	27	17.1
	Others	23	14.6
Site of data collection	Ras Al Khaimah college of dental	85	53.8
	Ajman University	73	46.2
Malocclusion classification	Malocclusion Class I	84	53.2
	Malocclusion Class II	32	20.3
	Malocclusion Class III	42	26.6

Continuous variables				
	N	**Minimum**	**Maximum**	**Mean ± S. D**
Age	158	15.00	64.00	28.27 ± 11.31

Analysis of Variance (ANOVA) was performed to find the mean differences between three types of teeth classification for each B-16, B-26, B-36, and B-46. The result showed that there is a statistically significant difference in percentage of force between the three types of malocclusions (I, II, and III) on the right molar side (B-16 and B-46) ($p < 0.05$). Moreover, the overall discrepancy showed a statistically significant difference in the three types of malocclusion classifications ($p < 0.05$). On the other hand, there was no statistically significant difference in the percentage of force between B-26 and B-36 ($p > 0.05$). (Table 2).

Table 2
Analysis of Variance (ANOVA) result of tooth malocclusion classification

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
B 16	Between Groups	713.518	2	356.759	7.114	.001
	Within Groups	7773.541	155	50.152		
	Total	8487.059	157			
B 26	Between Groups	39.344	2	19.672	.304	.738
	Within Groups	10029.258	155	64.705		
	Total	10068.601	157			
B 36	Between Groups	36.708	2	18.354	.300	.741
	Within Groups	9472.450	155	61.113		
	Total	9509.159	157			
B 46	Between Groups	793.968	2	396.984	20.648	.000
	Within Groups	2980.136	155	19.227		
	Total	3774.104	157			
Overall Discrepancy	Between Groups	17651.771	2	8825.886	205.455	.000
	Within Groups	6658.445	155	42.958		
	Total	24310.216	157			

Tukey-HSD test was used to detect significant intergroup differences. There was a statistically significant difference in B-16 between Malocclusion Classes I and II, with a mean difference of 4.43800 ($p < 0.05$). Additionally, post hoc showed a statistically significant difference between Malocclusion Class I and Class III with a mean difference of 4.11190 ($p < 0.05$). (Table 3).

Table 3

Multiple Comparison (Tukey HSD) of **B-16** between 3 types of tooth malocclusion classification

Dependent Variable: B 16						
Tukey HSD						
(I) Class	**(J) Class**	**Mean Difference (I-J)**	**Std. Error**	**95% Confidence Interval**		**Sig.**
				Lower Bound	**Upper Bound**	
Malocclusion Class 1 (B-16)	Class I (B16)	4.43800*	1.47115	.9566	7.9194	.008
	Class III (B16)	4.11190*	1.33833	.9448	7.2790	.007
Malocclusion Class II (B-16)	Class I (B16)	-4.43800*	1.47115	-7.9194	− .9566	.008
	Class III (B16)	− .32609	1.66173	-4.2585	3.6063	.979
Malocclusion Class III (B-16)	Class I (B16)	-4.11190*	1.33833	-7.2790	− .9448	.007
	Class II (B16)	.32609	1.66173	-3.6063	4.2585	.979
*. The mean difference is significant at the 0.05 level.						

Also, there was a statistically significant difference in B-46 between Malocclusion Classes 1 and 2, with a mean difference of -4.01806 ($p < 0.05$). Additionally, post hoc showed a statistically significant difference between Malocclusion Class 1 and Class 3 with a mean difference of -4.79841 ($p < 0.05$). (Table 4**).**

Table 4

Multiple Comparison (Tukey HSD) of **B-46** between 3 types of tooth malocclusion classification

Dependent Variable: B 46						
Tukey HSD						
(I) Class	**(J) Class**	**Mean Difference (I-J)**	**Std. Error**	**95% Confidence Interval**		**Sig.**
				Lower Bound	**Upper Bound**	
Malocclusion Class I (B-46)	Class II (B-46)	-4.01806*	.91089	-6.1736	-1.8625	.000
	Class III (B-46)	-4.79841*	.82865	-6.7594	-2.8374	.000
Malocclusion Class II (B-46)	Class I (B-46)	4.01806*	.91089	1.8625	6.1736	.000
	Class III (B-46)	− .78036	1.02889	-3.2152	1.6545	.729
Malocclusion Class III (B-46)	Class I (B-46)	4.79841*	.82865	2.8374	6.7594	.000
	Class II (B-46)	.78036	1.02889	-1.6545	3.2152	.729
*. The mean difference is significant at the 0.05 level.						

The mean of three types of tooth malocclusion classification was calculated to find the difference in net discrepancy. The post hoc analysis showed a statistically significant difference between the net discrepancy of Malocclusion Class 1 and the net discrepancy of Malocclusion Class II, with a mean difference of -26.20 ($p < 0.05$), but not with the net discrepancy of Malocclusion Class III ($p > 0.05$). Furthermore, the result showed a statistically significant difference between the Net Discrepancy of Malocclusion Class II the and Net Discrepancy of Malocclusion Class III, with a mean difference of 26.49320 ($p < 0.05$). (Table 5**).**

Table 5
Multiple Comparison (Tukey HSD) of Net Discrepancy between 3 types of tooth malocclusion classification

Dependent Variable: Net Discrepancy						
Tukey HSD						
(I) Class	**(J) Class**	**Mean Difference (I-J)**	**Std. Error**	**95% Confidence Interval**		**Sig.**
				Lower Bound	**Upper Bound**	
Net Discrepancy of Malocclusion Class 1	Class II	-26.20134*	1.36155	-29.4234	-22.9793	.000
	Class III	.29187	1.23863	-2.6393	3.2230	.970
Net Discrepancy of Malocclusion Class II	Class I	26.20134*	1.36155	22.9793	29.4234	.000
	Class III	26.49320*	1.53793	22.8538	30.1326	.000
Net Discrepancy of Malocclusion Class III	Class I	− .29187	1.23863	-3.2230	2.6393	.970
	Class II	-26.49320*	1.53793	-30.1326	-22.8538	.000
*. The mean difference is significant at the 0.05 level.						

Discussion

The current study aimed to determine the force distribution by using T-Scan as well as the NET discrepancies of forces generated at a maximum intercuspation position in the first molar region between the left and right sides of the mouth. Moreover, to determine the total average occlusal force of the first molars while standing at the maximum intercuspation position.

Malocclusion is the third major oral health problem, which may affect self-esteem due to aesthetic, speech, functional, and psychosocial changes, impairing the individual's quality of life [12]. Thus, appropriate indices for the analysis of malocclusions in population studies should be developed, emphasizing their functionality in determining the need and priority for treatment in addition to detecting objective signs and providing information that allows for careful social analysis and the rational allocation of human, material, and financial resources for orthodontic therapy in public health [13]. Occlusal bite force indicates functional mastication and tooth loading, which results in jaw elevations using muscles determined by the central nervous system and retrogressed from muscle spindles, mechanoreceptors, and nociceptors, modifying craniomandibular biomechanics. A stronger bite force results from a superior masticatory mechanism [14]. According to one study, bite force levels are employed to investigate mastication mechanics and therapeutic outcomes [15].

Wang's study showed that the T-Scan system's recordings are clinically useful in terms of accuracy and repeatability when looking at occlusal contact in the lateral excursion [16]. Saliva in the mouth doesn't change the way the T-Scan system records [17]. In the same way, other clinical and laboratory research has confirmed the T-Scan system's pressure sensitivity, accuracy, and stability of relative force loadings, as well as the repeatability of results [18].

The T-Scan, which can detect unequal distribution or relative occlusion, will highlight where excessive force is concentrated, and variations in occlusion over time will be more therapeutically useful than measuring absolute occlusion force because it can be misleading [17]. The T-scan system's advantages include not only its objectivity and reproducibility, but also its ability to identify occlusal changes over time. This system measured parameters that time-related factors, occlusal papers, and occlusal indices could not. Furthermore, this method is currently the only one accessible for investigating the dynamic properties of occlusion [13].

The current study found a statistically significant difference in the percentage of force in the right upper molar (B-16) between malocclusion classes 1 and 2, as well as classes I and III (4.43800 and 4.11190) ($p < 0.05$). Similarly, the proportion of force in the right upper molar (B-46) differed statistically between class malocclusion classes 1 and 2 (-4.01806) and (-4.79841), respectively ($p < 0.05$). However, no statistically significant difference in percentage of force was observed in any of the malocclusion classifications observed in (B-26 and B-36) classes I, II, or III ($p > 0.05$). T -Scan ability to report the difference in percentage of force on the right molar side was superior to the left side. The T-Scan occlusal pattern did not correspond with the malocclusion's angle categorization. Similarly, Agbaje et al. (2017) found that T-scan could not detect class II or class III malocclusions depending on the position of the teeth on the arch and relative to the opposing jaw [8]. Furthermore, Alhammadi et al. (2022) discovered that T-scan is less effective at detecting occlusal function patterns in patients with severe skeletal class III and skeletal class II malocclusion. Except for teeth 46, 44, and 41 [19]. González et al. (1997) reported no significant changes in the proportion of force on each tooth following four bites done in a maximal intercuspation position using a T-Scan [20]. However, significant scientific data supports the use of the T-Scan since it assesses relative occlusal forces and time objectively, correctly, and repeatedly. The computerized occlusal analysis method has been extensively researched and may offer exact time and force sequencing information to objectively evaluate occlusal contacts for better treatment outcomes [21]. Other research suggests that several parameters, such as the chewing side and the inactivity of the other side of the jaw, alter the accuracy of T-scan findings [22]. The expression of the higher muscle force on the preferred chewing side is connected with the higher occlusal force on that side. Lower cervical muscle activity has been linked to a decreased occlusal contact area [23]. Lower force applied on a non-preferred chewing side is related with a "weaker" chewing muscle, and therefore with a smaller occlusal contact area, whereas the smaller occlusal contact area is connected with a reduced occlusal force [24].

The current study found a statistically significant difference in the net discrepancy of Malocclusion Class I and Class II ($p < 0.001$), as well as the net discrepancy of Malocclusion Class II and Class II (p0.001). Age, gender, skeletal morphology, and malocclusion could all affect the net disparity of malocclusions, and the first molars are subjected to the most stress during chewing [21]. A study compared the occlusal strength parameters in 25 individuals with Angle class I, II, and III relationships with and without orthodontic treatment using T-Scan III, and the largest amount of force was concentrated on the second molars in both groups, followed by the first molars and second premolars, respectively. According to the study, the lateral incisors were subjected to less force. The study also indicated that the distribution of stresses on the teeth inside the arch varied between 0% and 35% [21]. In contrast, another study discovered no significant variation in force per tooth between the three categories of malocclusion classification I, II, and II. Furthermore, the occlusal forces were distributed evenly in the right and left jaws, and there was no significant difference in the occlusal force distribution in the right and left jaws [25]. Another study found that the occlusal forces in the right and left hemispheres had a balanced distribution that did not exceed 50% on one side [8]. Furthermore, it has been noted that the percentage of force on the non-working side observed in individuals who have undergone orthodontic treatment is similar to that of healthy individuals who have not undergone treatment, with a higher prevalence of group function occlusion pattern in the former [26]. Another study found that the increase in force distribution on the non-working side in individuals who had orthodontic treatment was induced by contacts, particularly on the second molar teeth [8].

Many studies have described the clear advantages of quantitative and qualitative T-scan processes over traditional qualitative approaches, especially because they avoid the practitioner's subjective judgment [27]. Numerous research has been conducted to assess the reliability and validity of T scan, indicating that it might be considered totally suitable for clinical application [28, 8]. Previous generations of T Scans I and II, which included significantly stiffer sensor foils, elicited opposing views on reproducibility [29]. However, Koos et al. found no flaws in their reliability analysis of the T Scan III [28], which was verified by another study [8, 30].

Limitations

The limitations of the current study were acknowledged and reported. The study was conducted solely for the purpose of evaluating the occlusion and developing a targeted treatment plan of evaluating the occlusion and developing a targeted treatment plan. Further studies are required to do a comparative evaluation before and after orthopedic treatment. Other limitations include accuracy in sensor calibration; hence, in our study, the calibration of the sensor was done meticulously, and if the sensor suffered damage midway through the procedure, the reading was discarded, and a new sensor was used for further readings. Interferences exceeding 0.6 mm were difficult to detect. As a result, while T-scan has high sensitivity and specificity as a diagnostic tool, large sample size studies are needed to confirm data reproducibility.

Conclusion

T-Scan technology provides detailed data about a patient's occlusion and can assist clinicians in determining how effective a treatment was. The T-Scan is a useful tool for assessing occlusal discrepancies and can be helpful during treatment planning and follow-up, especially for orthognathic surgery patients. T-scan could be used in orthodontic therapy in a simple and efficient way. Also, it turned out to be a useful tool for diagnosing problems and gave us new information about how therapies work. In this study, T-Scan showed that it can measure occlusal forces in timing in an objective, accurate, and repeated manner. The current study found that T-Scan was better able to report the difference in the percentage of force on the right molar side than on the left side. The T-Scan occlusal pattern did not match the angle classification of the malocclusion. Different factors could affect the accuracy of T-scan readings, such as chewing and inactivity on the other side of the jaw.

Declarations

"This study was conducted in accordance with the Helsinki Declaration and the Ethical Guidelines of the local ethics committees. Ajman University's Research Ethical Committee granted ethical permission/ approval for the study (Reference number# D-H-F-11). The study does not include any confidential or identifiable health-related data. A signed informed consent form was obtained from all the patients/ participants to participate in the study."

Consent for publication: Not Applicable

Availability of supporting data: The data that support the findings of this study are not publicly available due to restricted organization rules to share the data in public. However, the dataset is available with the corresponding author but with reasonable request.

Competing interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding: This work was supported by the Internal Research Grant (IRG) ***[Grant number 2021-IRG-DEN-12].***

Acknowledgment: None

Author contribution

HAT, MA: Conception and design of the work, **HAT, LA and VBD:** Acquisition of data, or analysis and interpretation of data. **HAT, LA, MA and VBD:** Drafting the article or revising it critically for important intellectual content. **HAT, LA, MA and VBD:** Final approval of the revision to be published.

References

1. Khadijah A, Turkistani MA, Alkayyal MA, Abbassy, Ayman A, Al-Dharrab MH, Zahran M, Melis, Khalid H, Zawawi. (2020): Comparison of occlusal bite force distribution in subjects with different occlusal characteristics, CRANIO®, DOI: 10.1080/08869634.2020.1830662

2. Panek H, Matthews-Brzozowska T, Nowakowska D, et al. Dynamic occlusions in natural permanent dentition. Quintessence Int. 2008;39(4):337–42.
3. Sayar G, Oktay H. Assessment of curve of spee in different malocclusions. Eur oral Res. 2018;52(3):127–30. https://doi.org/10.26650/eor.2018.475.
4. Eliyas S, Martin N. The management of anterior tooth wear using gold palatal veneers in canine guidance. Br Dent J. 2013;214(6):291–7.
5. Kim KY, Choi JY, Oh SH, Moon HW, Kim SH, Ahn HW, Kim KA, Nelson G. Computerized Assessment of Occlusion and Muscle Activity during Use of a Multilayer Clear Retainer: A Preliminary Study. Sensors. 2021;21(2):541. https://doi.org/10.3390/s21020541.
6. Littlewood SJ, Millett DT, Doubleday B, Bearn DR, Worthington HV. (2016). Retention procedures for stabilising tooth position after treatment with orthodontic braces. The Cochrane database of systematic reviews, 2016(1), CD002283. https://doi.org/10.1002/14651858.CD002283.pub4
7. Tai S. Clear Aligner Technique. Hanover Park, IL, USA: Quintessence Publishing Co., Inc.; 2018. pp. 74–6.
8. Agbaje JO, Casteele EV, Salem AS, Anumendem D, Shaheen E, Sun Y, Politis C. Assessment of occlusion with the T-Scan system in patients undergoing orthognathic surgery. Sci Rep. 2017;7(1):5356. https://doi.org/10.1038/s41598-017-05788-x.
9. Jaykumar R, Gade MJ, Agrawal, Sayali G, Dandekar MN, Soni KV, Jaiswal. Anil Ingole, Digital Occlusal Analyser T-Scan: A Review. J Res Med Dent Sci. 2021;9(11):187–93.
10. Aradya A, Nagarajagowda R, Basavaraju RM, Srinivas S, Kumararama SS. Influence of T-scan System on Occlusion Correction of Implant Supported Prostheses: A Systematic Review. J Contemp Dent Pract. 2022;23(1):105–17.
11. Faul F, Erdfelder E, Lang AG, et al. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175–91.
12. Snowden CB, Miller TR, Jensen AF, Lawrence BA. Costs of medically treated craniofacial conditions. Public Health Rep. 2013;118:10–7.
13. Moimaz S, Gonçalves C, Chiba F, Garbin A, Saliba T. Malocclusion indices and their applications in public health: a review study. ARCHIVES OF HEALTH INVESTIGATION. 2021;10:1156–63. 10.21270/archi.v10i7.5260.
14. Subramaniam P, Girish Babu KL, Ifzah. Evaluation of occlusal forces in different stages of children – an exploratory study. Saudi J Oral Sci. 2018;5:11–6.
15. Prabahar T, Gupta N, Chowdhary N, Sonnahalli NK, Chowdhary R, Reddy VR. Comparative Evaluation of Occlusal Bite Force in Relation to the Muscle Activity in the Mixed Dentition Children of Age Group 9–12 Years: A T-scan Analysis. Int J Clin Pediatr dentistry. 2021;14(Suppl 1):29–S34. https://doi.org/10.5005/jp-journals-10005-2019.
16. Thumati P, Thumati RP, Poovani S, Sattur AP, Srinivas S, Kerstein RB, Radke J. A Multi-Center Disclusion Time Reduction (DTR) Randomized Controlled Occlusal Adjustment Study Using Occlusal

Force and Timing Sensors Synchronized with Muscle Physiology Sensors. Sensors. 2021;21(23):7804. https://doi.org/10.3390/s21237804.

17. Lee SM, Lee JW. Computerized occlusal analysis: correlation with occlusal indexes to assess the outcome of orthodontic treatment or the severity of malocculusion. Korean J Orthod. 2016;46(1):27–35. https://doi.org/10.4041/kjod.2016.46.1.27.
18. Sutter B. (2019). Digital Occlusion Analyzers: A Product Review of T-Scan 10 and Occlusense. 2.2–31.
19. Alhammadi MS, Qasem AAA, Yamani AMS, et al. Skeletal and dentoalveolar effects of class II malocclusion treatment using bi-maxillary skeletal anchorage: a systematic review. BMC Oral Health. 2022;22:339. https://doi.org/10.1186/s12903-022-02363-3.
20. González Sequeros O, Garrido García VC, García Cartagena A. Study of occlusal contact variability within individuals in a position of maximum intercuspation using the T-SCAN system. J Rehabil. 1997;24(4):287–90. https://doi.org/10.1046/j.1365-2842.1997.00506.x.
21. Qadeer S, Özcan M, Edelhoff D, Van Pelt H. Accuracy, Reliability and Clinical Implications of Static Compared to Quantifiable Occlusal Indicators. Eur J Prosthodont Restor Dent. 2021;29(3):130–41. https://doi.org/10.1922/EJPRD_2202Qadeer12.
22. Haralur SB, Majeed MI, Chaturvedi S, Alqahtani NM, Alfarsi M. Association between preferred chewing side and dynamic occlusal parameters. J Int Med Res. 2019;47(5):1908–15. 10.1177/0300060519827165.
23. Komiyama O, Arai M, Kawara M, Kobayashi K. Influence of Occlusal Contact on Cervical Muscle Activity during Submaximal Clenching. J Rehabil. 2004;31:417–22. http://dx.doi.org/10.1111/j.1365-2842.2004.01265.x. [Citation Time(s):2].
24. Bicaj T, Pustina T, Ahmedi E, Dula, LindaLila Krasniqi, ZanaTmava-Dragusha, ArlindaAdemi-Abdyli, ResmijeAjeti, Nexhmije. (2015). The Relation between the Preferred Chewing Side and Occlusal Force Measured by T-Scan III System. Open Journal of Stomatology. 05. 95–101. 10.4236/ojst.2015.54014.
25. Dzingutė A, Pileičikienė G, Baltrušaitytė A, Skirbutis G. Evaluation of the relationship between the occlusion parameters and symptoms of the temporomandibular joint disorder. Acta Med Lituanica. 2017;24(3):167–75. https://doi.org/10.6001/actamedica.v24i3.3551.
26. Aung PT, Kato C, Abe Y, Ogawa T, et al. Functional Analysis of Rhythmic Jaw Movements Evoked by Electrical Stimulation of the Cortical Masticatory Area During Low Occlusal Loading in Growing Rats. Front Physiol. 2020;11:34.
27. Afrashtehfar KI, Qadeer S. Computerized occlusal analysis as an alternative occlusal indicator. Cranio. 2016;34:52–7.
28. Koos B, Godt A, Schille C, Goz G. Precision of an instrumentation-based method of analyzing occlusion and its resulting distribution of forces in the dental arch. J Orofac Orthop. 2010;71:403–10.

29. Cerna M, Ferreira R, Zaror C, Navarro P, Sandoval P. Validity and reliability of the TScan(®) III for measuring force under laboratory conditions. J Oral Rehabil. 2015;42:544–51. https://doi.org/10.1111/joor.12284.
30. Chen YJ, Yao CC, Chang ZC, Lai HH, Lu SC, Kok SH. A new classification of mandibular asymmetry and evaluation of surgical-orthodontic treatment outcomes in Class III malocclusion. J Craniomaxillofac Surg. 2016;44:676–83. https://doi.org/10.1016/j.jcms.2016.03.011.

Figures

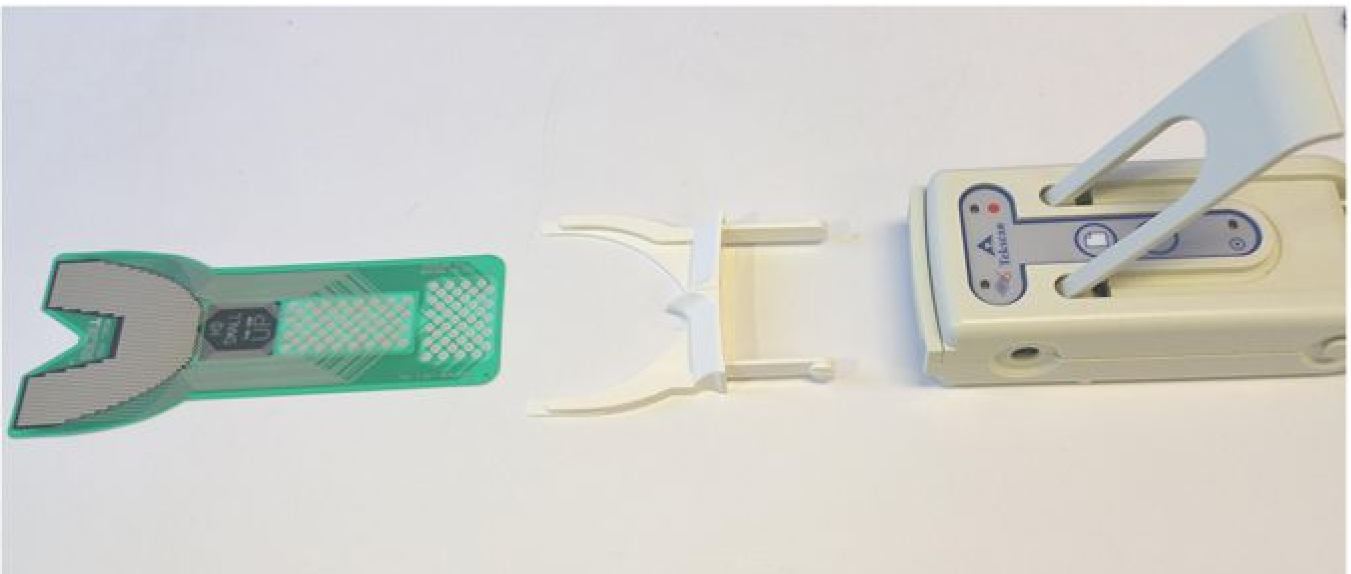

Figure 1

T-Scan system

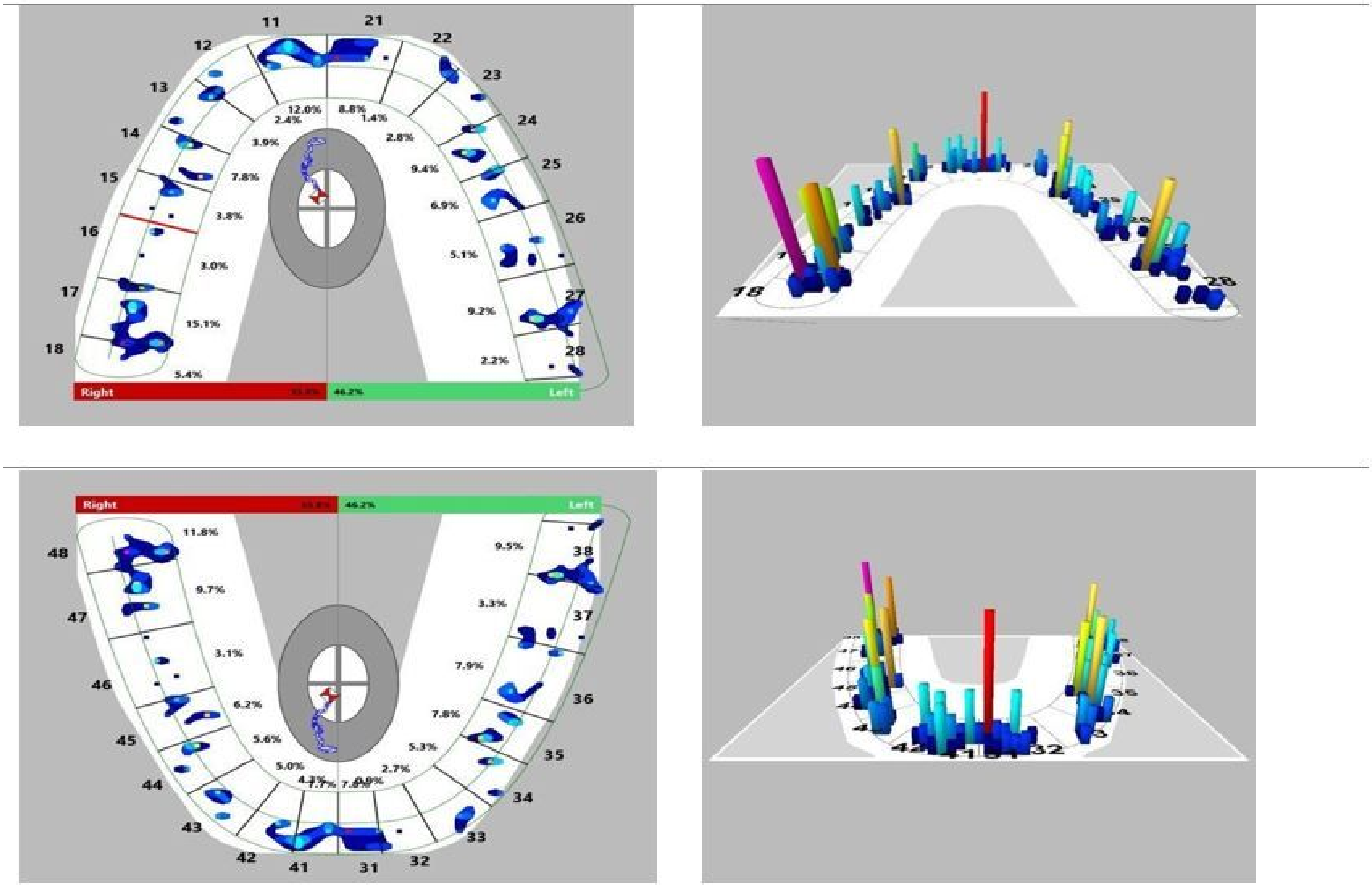

Figure 2

2-D and 3-D Images of Occlusal contacts and force generated

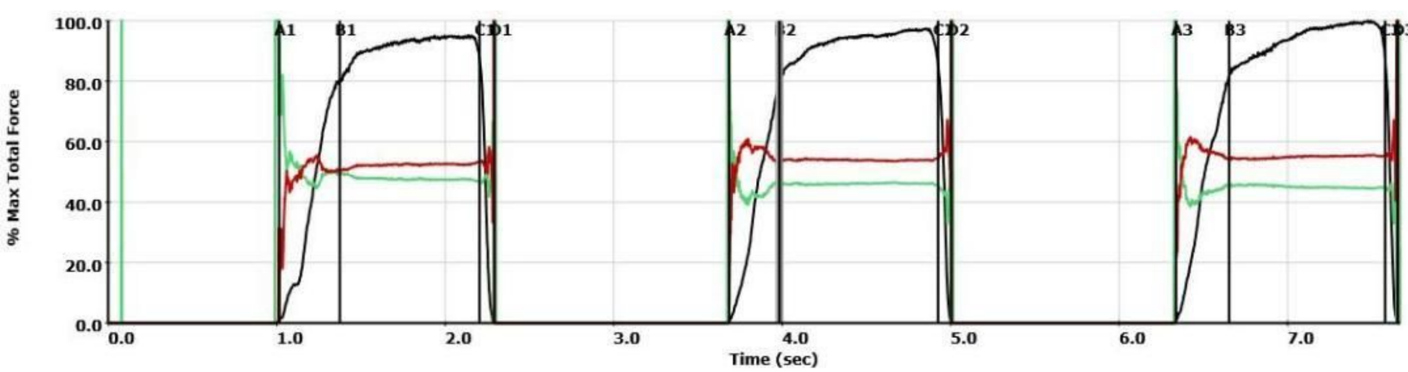

Figure 3

Graph on Maximum force generated with time on occlusal contact