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An evaluative analysis of dental occlusion using classical and digital method - T-Scan system

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Abstract

Background. Dental occlusion plays an important role in the correct functioning of the masticatory system, as any restorative and prosthetic procedure will have an impact on the occlusion.

Aims. The aim of the study was to perform an evaluative analysis of the dental occlusion in static and dynamic positions of the mandible using the classical method with the articulating paper and the digital T-Scan method. Also, to investigate the differences between the two methods in the precise identification of the number and location of the occlusal contacts.

Methods. The analysis of dental occlusion was performed on ten patients aged 22 - 50 years and categorized into two groups. The clinical method used 200 and 40 μm articulating paper (Bauch, Germany) and 12 μm Shimstock foil (Hanel, Germany) in evaluation the occlusal contacts in maximum intercuspation, propulsion and right / left laterality. The computerized analysis of static and dynamic occlusion for the two groups employed the T-Scan Novus v10 system (Tekscan Inc., Germany), recording the forces from the occlusal contacts.

Results. In Group 1, 51% of occlusal contacts were found in maximal intercuspation, using articulating paper and 49% using T-Scan. In Group 2, 54% of contact points were identified by articulating paper and 46% by T-Scan. The two methods investigated the static and dynamic occlusion have shown similar results, with no statistically significant differences.

Conclusions. Although there is currently no gold standard for dental analysis, in clinical practice the classic method using articulating paper should be used initially, followed by the computerized method using the T-Scan system to ensure an accurate occlusal diagnosis and appropriate treatment for patients.

Keywords: occlusal analysis, digital method, T-Scan.

Introduction

The masticatory system includes the temporomandibular joint, the masticatory muscles, and the dental arches, in which the correct alignment of the teeth maintain their stability by making the correct occlusal contacts (Duminil et al., 2013). The position of the teeth in the jaws affects the dental occlusion and plays an important role in the oral functions such as chewing, phonation, aesthetics, and posture. The occlusal relationships can have impact on the normal functioning of the masticatory system; therefore, the accurate analysis is important to ensure the stable occlusion and the harmonious functions (Orthlieb, 2013). The discrepancies in occlusal relationships in various mandibular positions can cause the persistent pain in the temporomandibular joint and masticatory muscles (Buduru, 2018). The maximal intercuspation (MI) position exhibit the highest number of occlusal contacts, and the dental occlusion in MI is subjected to change over time (Dawson, 2006; Qadeer & Tür, 2023).

The clinical method of analyzing the occlusal contacts between maxillary and mandibular teeth in different positions of the mandible uses a variety of indicators, such as articulating papers, silk strips, Shimstock foil, which are made of materials with color transfer for marking occlusal contact areas (Millstein & Maya, 2001; Jaykumar et al., 2021). Articulating papers, developed by the Bausch company in 1953, are available in different colors, dimensions, and compositions, typically packaged in boxes or booklets. Predominantly, these papers are red or blue, with thicknesses commonly at 40 and 200 μ (Bausch, 1953). Thick blue paper (200 μ) ensures durable contacts recording in maximum intercuspation, while thick red paper (200 μ) facilitate the dynamic occlusion diagnosis. Thin blue paper (40 μ) provides patient comfort

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and precision in marking the occlusal contacts, and thin red paper (40 μ) permits the checking the occlusion for prosthodontic restorations, including crowns and fixed partial prosthesis (Denton & Garcia, 2014). The Shimstock foil, thinner at 8 to 12 μ, identifies the existence of occlusal contacts, the color version (Arti-Fol®, Bausch) is applied for better and faster recording (Bausch, 2023).

In the recent years, rapid advancements were made in dentistry due to the increasing patient demands. The importance of digital methods in occlusology has been recognized for providing the comprehensive dental care and treatment (Nalini & Sinha, 2018). Digital occlusal analysis often involves the use of intraoral scanners, which capture high-resolution images of the teeth and their occlusal surfaces. These images can then be analyzed using specialized software to evaluate various aspects of occlusion, such as occlusal contacts, interferences, and discrepancies in tooth alignment (Qadeer et al., 2021). Several digital occlusal devices are available for occlusal analysis and therapy such T-Scan, Occlusense, Trios 3, CAD/CAM systems (Risciotti et al., 2024).

The T-Scan allows the recording of dental occlusion in both maximum intercuspation (MI) and centric relation. Moreover, it facilitates the occlusal analysis in propulsion and laterality. Additionally, it aids for assessment of temporomandibular joint pains during the dynamic movements. The T-Scan enables the observation of dysocclusion time during movements and provides analysis of force/time graphs throughout these movements. Furthermore, it is effective in detecting nonfunctional obstacles such as interferences, premature contacts during static and dynamic occlusion (Kerstein, 2015; Bozhkova, 2016).

Objectives

The objective of the study was to analyze the occlusal contacts between the teeth by using the classical and the digital methods both in static occlusion (maximal intercuspation) and in dynamic occlusion (propulsion and right/left laterality) and also to evaluate the differences between the patients by both two methods.

Hypothesis

The first null hypothesis states that there are no statistically significant differences in the number and distribution of occlusal contacts between the two methods in maximum intercuspation in the two groups of patients. The second null hypothesis affirms that there are no statistically significant differences in the number and distribution of occlusal contacts between the two methods in propulsion and laterality in the two groups of patients.

Material and methods

a) Period and place of the research

The study was conducted between March and June 2023 at the Department of Prosthodontics in collaboration with a private dental clinic from Cluj-Napoca.

b) Subjects and groups

The study was performed on 10 patients, male and female, ranging in age from 22 to 50 years and categorized into two distinct groups, five patients were included in each of the two groups. The inclusion criteria for Group 1 were the presence of at least 14 natural teeth per arch with Angle Class I, no fillings on the first molars, and for Group 2 the presence of a total implant-supported bridge in one or both arches. For both groups, cooperative patients with good general and oral health, no anxiety and no evidence of temporomandibular dysfunction were included. The exclusion criteria for group 1 were the presence of edentulous spaces or any prosthetic restoration and for group 2 the presence of natural teeth in one or two arches.

c) Used methods

Clinical analysis of static occlusion

Clinical analysis of occlusion was first performed by the classical method using articulating paper of 200 and 40 μm thickness, placed between the maxillary and mandibular teeth in static occlusion – maximum intercuspation (MI) position followed subsequently by dynamic occlusion in propulsion and laterality positions of the mandible.

Evaluation of the maximal intercuspation

Clinical assessment of the static occlusion began with the establishment of the Angle class on the first molars on both sides. Patients were instructed to perform the rapid opening and closing movement with reduced amplitude. The teeth were then dried, and the patients were asked to repeat the movement, this time with blue articulating paper 200 μ applied between the right and left hemi-arches using two Miller tweezers (Fig. 1). The contact points marked in blue were then erased with a cotton roll. To refine the marks and improve accuracy, the patients repeated the movement using 40 μ blue articulating paper. The occlusal contacts were identified, photographed and analyzed. To ensure the presence of the contact points, the position of the MI could be assessed using 12 μ Shimstock foil; if there was any contact, pulling on the paper resulted in it either sticking or tearing.

Fig 1 – The bilateral positioning of blue articulating paper between two arches for recording the occlusal contacts in MI with use of two Miller tweezers.

Clinical analysis of dynamic occlusion in the excentric movements

- *Evaluation of propulsion movement*

The patients performed the movement to obtain the maximum intercuspation position, with blue articulating paper 200 μ applied between the teeth. The blue contact points were visualized, photographed, and analyzed. The red 200 μ articulating paper were then placed, and the patients

were instructed to perform the propulsion movement until to the edge-to-edge position before returning to the MI. The red trajectories marked on the teeth during the movement were identified, photographed and analyzed (Fig. 2 a, b). After erasing the blue and red marks with a cotton roll, the patients repeated the sequence of movements using blue and then red articulating paper, each 40 µ thick, for refinement of marks and improvement of accuracy. The contact points and red marks were again analyzed and photographed, noting the number of marks, the trajectory and intensity. The movement was repeated with Shimstock foil, placed between the pairs of antagonistic teeth while the patients performed the propulsion, in order to detect the premature contacts and the occlusal interferences.

a)

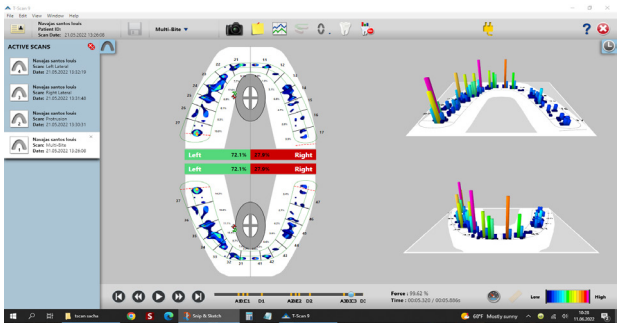
b)

Fig. 2 – Assessment of dynamic occlusion in excentric movements of the mandible - propulsion and laterality: **a)** Trajectories on the palatal surfaces of the maxillary anterior teeth with red articulating paper in propulsion and in right / left laterality; **b)** Marks on the mandibular teeth made with red articulating paper in these movements.

- *Evaluation of lateral movements*

Prior to the evaluation, patients were instructed to achieve the MI position and then the right lateral movement, visually analyzing the guiding teeth during and in the final position, the type of lateral guidance. After drying the teeth, the patients were asked to perform the movement to achieve MI with blue articulating paper between the teeth. Contact points were identified, photographed and analyzed. Red articulating paper 200 µ is then placed between the right hemi-arches and the patient performs the right lateral movement to reach the final position before returning to MI. The blue contact points and red marks left by the movement are identified, photographed and analyzed, with the blue and red marks then erased. The sequence of movements is repeated using blue and then red articulating paper, each 40 µ thick, to refine the marks and increase precision. The contact points and red marks are again determined, analyzed and photographed, paying attention to their number, trajectory and intensity. To detect interference and premature contacts, the procedure can be repeated with Shimstock foil 12 µ inserted between each pair of antagonistic teeth while the patient performs the right lateral movement. The whole procedure was then repeated for the left lateral movement.

The dental occlusion of the patients in both groups was digitally analyzed using the T-Scan Novus v10 (Tekscan, Germany) in MI, propulsion and lateral movements (Fig. 3 a, b).



a)

b)

Fig. 3 – Digital assessment of dental occlusion with T-Scan system: **a)** Occlusal analysis of MI position with T-Scan; **b)** T-Scan Novus model including the sensor, the handle, a Miller tweezer and blue articulating paper.

The digital protocol for assessing the dental occlusion by T-Scan system commenced with the input of the patient's details into the software interface. The morphology of the teeth was identified, and the mesiodistal dimension of each tooth was measured and recorded. The appropriate sensor was attached to the T-Scan handle subsequent to the selection the size of the arch and subsequent connection to the computer. The recording started with the patient performing the MI on the sensor. Upon completion of the MI recording, the dynamic occlusion relationships in propulsion and laterality were captured. In the case of propulsion movement, the "protrusion" option was selected from the software menu and the recording was initiated by

starting from the MI, the movement was performed three to four times and returning to the MI each time. Following the selection of the 'mediotrusion right and left' option from the software menu, the recording was initiated while the patients were guided from the MI to perform the lateral movement to the right and left, repeating the movement three to four times before returning to the MI after each repetition. The data obtained from each recording sequence was stored on a computer and subsequently analysed for occlusal purposes.

d) Statistical analysis

The data was statistically analyzed in Microsoft® Excel® 2021 MSO (version 2406) using the data analysis function. The independent samples Student's t-test was employed for a comparative analysis of the data and to ascertain the existence of statistically significant differences between the averages of the two groups of patients in terms of the number and location of occlusal contacts obtained with the two methods – articulating paper and T-Scan.

Results

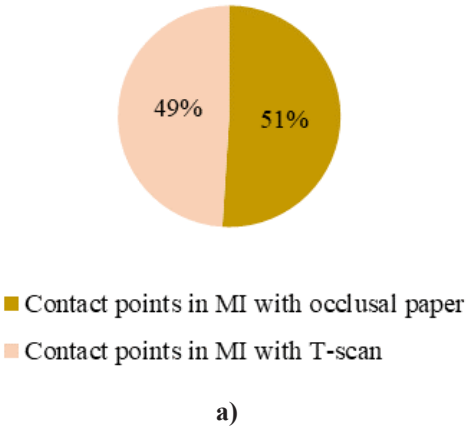
In order to analyze dental occlusion in the MI position, the number and location of occlusal contacts between the maxillary and mandibular teeth were recorded for patients from the two groups. The overall number of all contacts present in each patient from each group was then calculated in order to determine the effectiveness of the two methods (Fig. 4 a, b).

a)

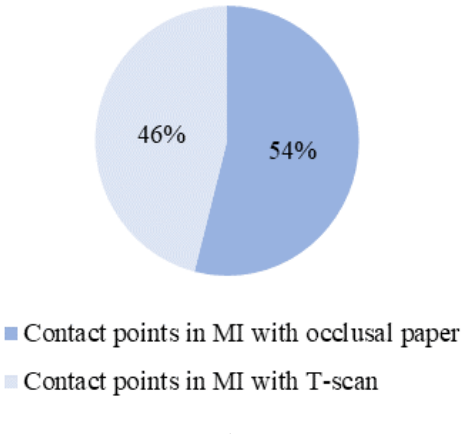
b)

Fig. 4 – Occlusal contacts in MI with blue articulating paper: **a)** Contacts on the maxillary teeth in static occlusion marked with articulating paper of 200 µm thickness; **b)** Contacts on the mandibular teeth in static occlusion using articulating paper of 40 µm thickness.

Regarding the number of occlusal contact points in the MI record using the two methods of analyzing, their percentages are shown in Fig 5 a, b. Group 1 showed a relatively balanced percentages; 51% of contact points were found using articulating paper and 49% of contact points in IM were identified using T-Scan. Group 2 revealed a small difference in the number of occlusal contacts, with 54% identified through articulating paper and 46% through T-Scan.



a)



b)

Fig. 5 – Total number of occlusal contacts in MI using the occlusal paper and T-Scan methods: **a)** Percentages of the number of contact points in the intercuspal position in Group 1; **b)** Percentages of the number of contact points in the intercuspal position in Group 2.

In Group 1, the value of the T-test was p=0.73, the mean number in distribution of contact points was 23.6 when using articulating paper, and 22.6 when using T-Scan. In Group 2, the value of the T-Test was p=0.26, the mean number in the distribution of contacts points in the MI for articulating paper was 25.6, and for T-Scan 22.2. Thus, there are no statistically significant differences between the two groups, in relation with the two methods (Fig. 6 a, b).

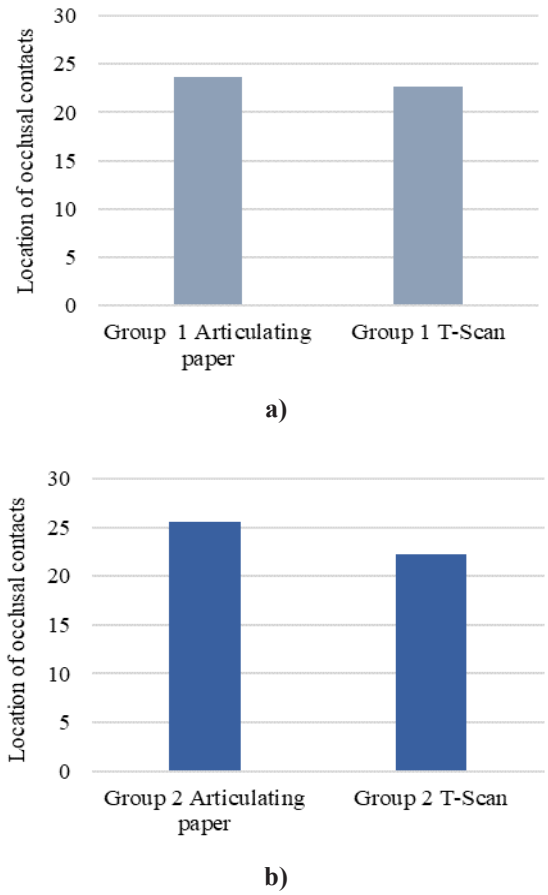


Fig. 6 – Analysis of distribution of occlusal contacts in MI for the two groups according to the two methods: **a)** Distribution of occlusal contacts in static occlusion in Group 1; **b)** Distribution of occlusal contacts in static occlusion in Group 2.

The analysis of these graphs showed that there was no significant difference between the two methods used, regardless of the groups of patients involved. Thus, it was shown that there was a certain degree of agreement between the classic and the digital methods in identifying occlusal contact points in the MI.

In the propulsion movement, the number of engaged teeth pairs guiding and supporting the anterior movement of mandible, passive interferences and premature contacts were analyzed for the two groups of patients with both methods (Fig. 7 a, b).

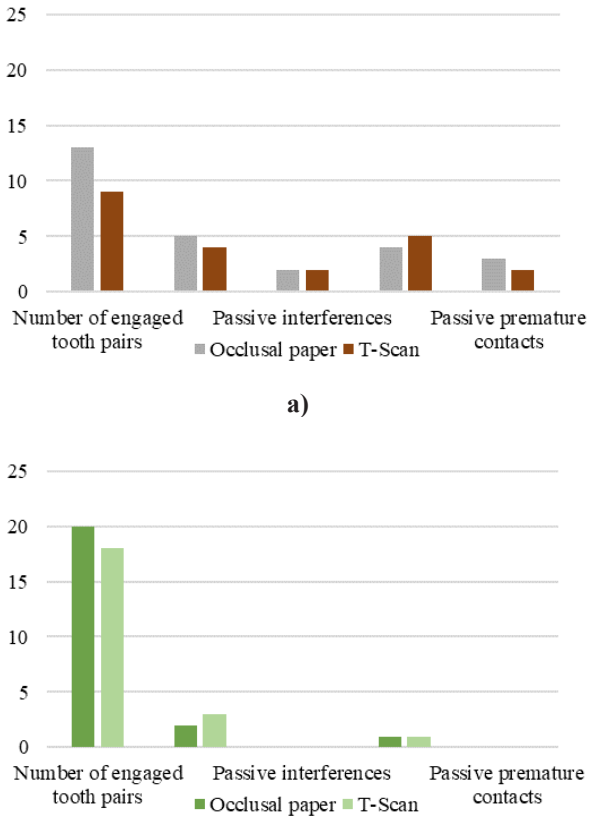


Fig. 7 – Occlusal parameters analyzed in propulsion movement using the two analyzing methods: **a)** Number of engaged tooth pairs, occlusal interferences and premature contacts in Group 1; **b)** Number of engaged tooth pairs, occlusal interferences and premature in Group 2.

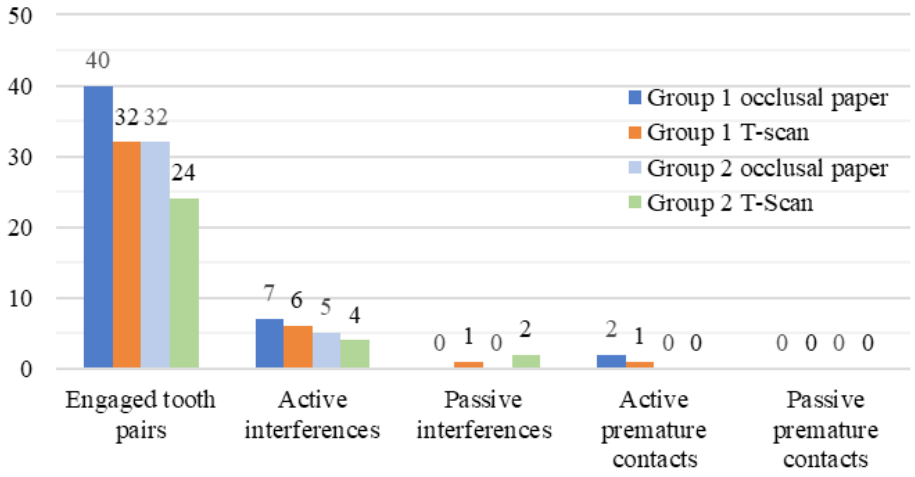


Fig. 8 – Occlusal parameters investigated in lateral movements within the two groups of patients using the two recording methods.

These charts highlight that the two methods used for the occlusal analysis determine statistically similar results. The values gathered within the two groups of five patients are relatively identical.

Left and right lateral movements were also assessed in the study. Additionally, as with the other analyses, both patient groups and both methods were considered.

Figure 8 shows that there is no significant difference between the occlusal parameters for the occlusal paper and T-Scan methods in the right and left lateral movements. However, there was a consistent tendency toward the articulating paper, with a slightly different number of occlusal contacts each time.

Discussion

The statistical analysis of the data showed that the two null hypotheses are validated. The results confirmed the first null hypothesis, which claimed that the differences between the two methods of 40 μ articulation paper and T-Scan in maximal intercuspation are insignificant in number and distribution of occlusal contacts for the two groups of patients. However, a slight tendency can be observed for the clinical method using the articulating paper of 40 μ to highlight some additional contact points, especially in the group of patients with implant-supported bridges. The second null hypothesis was confirmed at the statistical study of the results, indicating that no statistically significant differences in the number and distribution of occlusal contacts between the two analysis methods in propulsion and laterality in the two groups of patients.

The absence of statistically significant differences in the analysis of the occlusal contacts in static and dynamic occlusion indicated that classical and digital methods showed similar results, and the small variations had no statistical significance.

The classical method using the articulating paper is a subjective evaluation method, based on the clinician's experience, while the digital method using the T-Scan system is an objective method, based on quantitative information about the number and location of the forces occurring at the moment of the occlusal contact.

A study conducted by Buduru et al. (2019) analyzed dental occlusion in patients using articulating paper, T-Scan, and the Trios intraoral scanner. The patients underwent orthodontic, prosthodontic, and implant treatment, respectively. The study found no significant difference in results between the three methods, although the T-Scan differed slightly. Nonetheless, these results were useful in elucidating the pathology and establishing the occlusal diagnosis.

Another study carried out by Bozhkova et al. (2021) aimed to determine the optimal method for quantitative and qualitative occlusal analysis. The classical method provided more details on the quantitative aspect of the analysis, while the digital method was more precise qualitatively. The study concluded that the preferred method should be a combination of the classical method using articulating paper and the digital method employing the T-Scan.

Agbaje et al. (2017), the T-Scan was used for occlusal analysis before and after orthognathic surgical treatment in 40 patients. The study demonstrated the accuracy of T-Scan in occlusal analysis and its real value in orthognathic surgery. Because the data was recorded electronically, it was easy to compare results, even months apart, without compromising accuracy as with articulating paper, which requires operator-dependent photographic documentation for data backup.

The review conducted by Afrashtehfar & Qadeer (2016) focused on the preferred method of occlusal analysis. The study concluded that computerized occlusal analysis systems, such as T-Scan, provide increased accuracy compared to classical methods. The digital methods have advantages that are not available with the classical method, such as the increased accuracy of occlusal contacts.

Although the results of our study using both methods showed the minimal variation, T-Scan demonstrated the benefits of its use by being able to accurately identify the number, distribution and intensity of the occlusal contacts and visualize them in real time on the computer screen. The subjective limitations of the use of articulating paper in the assessment of dental occlusion relate to some aspects of the oral cavity: the moisture provided by saliva can influence the marking of contact points on the teeth, the interpretation of the marks depending on the clinician's experience, the lack of information on the forces developed at the occlusal contacts, which can influence the clinical decision and the treatment plan. Further studies are needed in more clinical cases to evaluate the dental occlusion using classical and digital tools to determine the effectiveness of the optimal occlusal analysis method in diagnosis and treatment.

Conclusions

1. From the results obtained by using the two analysis methods, it can be concluded that the articulating paper marked the number and location of occlusal contacts, but the T-Scan accurately identified the occlusal contacts and recorded the functional mandibular excursive movements in propulsion and laterality.
2. The efficient clinical approach for occlusal analysis might be the combined utilization of articulating paper and the T-Scan: the first occlusal analysis with articulating paper and the second with T-Scan, which provides additional information.

Conflict of interest

No conflict of interest to declare.

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