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Original Article

Computerized Assessment of Articulating Paper Occlusal Adjustment for Implant Crowns Restoring Modification Spaces of Kennedy Class II Cases

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Abstract

Objective: The study was conducted to evaluate the effectiveness of articulating paper-guided occlusal equilibration for single implant crowns used to restore the modification space anterior to the second premolar pier abutments in mandibular Kennedy class II cases using T-Scan.
Subjects and methods: Eighteen patients had unilateral distal extension spans with isolated second premolars were selected. Removable partials were constructed after restoring the modification spaces with implant-supported screw-retained porcelain-metal crowns. The occlusal contacts on the implant crowns were marked using articulating paper, standardized photographs were taken to compare with T-scan recordings, and the percentage of force applied to the implant abutment crowns (POFI) and contralateral teeth (POFT) was evaluated using T-scan before and after the adjustments. The data were analyzed using the paired t-test and the student t-test, while regression analysis was carried out to assess the frequency of matchings and non-matchings between the paper marks and the T-scan. **Results:** The POFI values were decreased, and the POFT values were increased, after articulating paper occlusal adjustments however, the changes were not significant for the natural teeth. The correlation coefficient between the most apparent paper marks and the number of red columns presented in T-scan recordings indicated a fair correlation. **Conclusion:** Using the resemblance of paper markings as a guide to determine forceful contacts is not based on evidence, and is very susceptible to error. However, for clinical correlation, occlusal accuracy in such cases won't suffer if more easily feasible, simpler ways are used to guide occlusal equilibration.

Keywords: Computerized occlusal analysis, T-scan, articulating paper, Dental implant occlusion, implant-supported crowns.

Introduction

Even though it is a rare course of action, a few strategically placed dental implants combined with the remaining dentition can help to achieve a more favorable removable partial denture design in circumstances where fixed rehabilitation is impractical. Dental implants may play a critical and very significant role in partial denture retention as well as stability and support. (1)

The abutment teeth that are most distal are constantly subjected to distal tipping, rotation, torque, and horizontal movement as a result of the functional forces received by them in distal extension bases, which cause a rotation axis to be created around them. In case of additional mesial contact absence, those most distal abutments will also be prone to mesial tipping. This will cause mesiodistal torquing, which will quickly destroy the supporting bone and periodontium. (2, 3)

To reduce damaging stresses applied to pier abutments, various treatment approaches have been suggested. One method involves utilizing a fixed partial denture to splint the isolated abutment to the closest tooth. [2, 3]. An intact dental arch can also be created by restoring the modification space in front of the pier abutment with an independent implant-supported crown, and it has been reported that this method can take out the pier abutment-related fulcrum-like circumstance. [4]

Because dental implants lack the periodontium's shock-absorbing function and have lower proprioceptive feedback and tactile sensitivity in the absence of periodontal mechanoreceptors than natural teeth, achieving the ideal implant occlusion is crucial for maintaining the health of their surrounding tissues and avoiding implant-related complications. The mechanical stress and strain from occlusal loading determine the health of the associated hard and soft tissues after rigid fixation of the dental implant is established. Thus, excessive force from accidental occlusal interactions is one of the major contributors to peri-implantitis and bone loss surrounding implants. Additionally, mechanical issues like screw fractures and loosening as well as prosthesis and implant fractures may also result from occlusal overloading. [5]

For prosthetic rehabilitation using dental implants, Dr Carl Misch created the idea of implant-protected occlusion (IPO). Reduced biomechanical stress on the implant-bone interface and on the prosthesis are the aims of the IPO concept. A prosthetically and biologically acceptable implant interface is guaranteed by the optimal occlusal scheme for an implant prosthesis that is capable of maintaining the long-term stability of the marginal bone, soft tissues, and prosthesis itself. The IPO principles take into account several factors to reduce stress on the implant system such as; the pre-existing occlusion, the implant body angle to the occlusal load, the cusp angle of the implant crowns, the width of the occlusal table, the mutual protection in the articulation, the cantilever or offset loads, the shape of the crown, the position of the occlusal contact, the timing of the occlusal contacts, etc. [6]

Due to the intrinsic disparities between implants and natural teeth when they are placed in the same arch, the "timing" of occlusal interactions is crucial to the force distribution. By delaying the implant occlusal contacts so they experience less occlusal force until after the neighboring natural teeth occlude and move inside the PDL fibers, "timed" occlusal contacts seek to accommodate for the mobility disparities between teeth and implants. As a result, the occlusal stress can be distributed evenly, and higher loads and early implant interactions can be avoided. The implant crown should initially avoid light biting pressure due to the initial difference in vertical movement between the natural tooth and the implant; however, after a stronger occluding pressure is applied, the implant crown should come into contact. [6, 7]

High-force contacts are frequently identified using articulating papers, which leave a mark where the contact subsists according to their width, thickness, and kind of dye. Even though there is no scientific proof that the ink spots may assess different occlusal force levels by their size or color depth, articulating paper is still a commonly used occlusal indicator that supposedly locates forceful tooth interactions. The unproven and non-scientific assumptions that bigger-sized and darker markings are thought to constitute a powerful occlusal contact, while lighter and minimal-sized markings are believed to indicate less powerful contacts, are the foundation of the clinical usage of articulating papers in the course of routine dental care. [8, 9]

Quantifiable Occlusal indicators have been developed to overcome the limitations and subjectivity of static occlusal indicators, the T-Scan Computerized occlusal analysis technology is superior in that T-Scan can record the very first contact of a tooth, relative force, and timing. The captured occlusal data is processed by the related software, and the outputs are displayed as two-dimensional and 3D illustrations. The percentages of applied forces per tooth are represented as bars and columns on the same tooth in graphical displays. Unlike conventional detection methods, "light contact" is interpreted from the T-scan in terms of both the percentage of bite force and the density of bite force with different colors. There is sufficient evidence that points out that the use of the T-Scan III system permits the application of the time-delayed loading concept on dental implants, by loading the natural teeth first with occlusion time (OT< 0.2s) followed by loading the implant restoration with OT< 0.4s (delay after the adjacent natural teeth). Sensitivity, reliability, and reproducibility are the major advantages of T-scan digital occlusion analysis. (9, 10, 11, 12,13)

Some believe that articulating paper is effective in guiding implant occlusion calibration and adjustment and still rely on it, (14, 15) However, several studies using the T-Scan technology investigated the relationship between paper mark size and the occlusal force levels contained within the same ink contacts. The results of all those studies demonstrated that determining high-force or low-force occlusal contacts based on contact size and color depth was incredibly inaccurate. and that using quantifiable T-scan technology instead was the most accurate subjective method for determining occlusal force levels. (9,16, 17, 18, 19)

This in vivo study was thus carried out to determine whether or not the use of the articulating paper to calibrate the occlusal contacts of a single implant restoration is sufficient to achieve the goals of equilibrated implant-prosthetic occlusion following the IPO concept. This was accomplished through; the objective assessment of the changes in the percentage of biting force after articulating paper-driven occlusion adjustments using the T-scan computerized occlusal analysis, and by subjectively comparing the articulating paper markings and the T-scan recordings for the occlusal points evaluation.

The null hypothesis was that; further investigations using the T-scan occlusal analyzer as a quantifying, and non-subjective occlusal indicator would not disprove or refuse the occlusion of the implant restoration that had been accepted as ideal based solely on articulating paper analysis.

Subjects and Methods

This investigation was carried out in the prosthodontic department, faculty of dentistry, Ain Shams University. The study design was approved by the ethics committee of the faculty of dentistry, at Ain Shams University. Each subject received instructions outlining the study protocol before participating, had the chance to ask questions about it, and was given the option to accept or reject taking part in the study. All participants provided their informed consent.

G*Power version 3.1.9.7 (20) was used to calculate the sample size based on the findings of a prior study. (9) To have enough power to apply a two-sided statistical test to the null hypothesis that there is no difference between the tested elements, a power analysis was created. Using an alpha level of 0.05 and a beta level of 0.2, i.e., with a power of 80% and an effect size (d) of (1.20) calculated based on the results of a previous investigation (9) The predicted sample size (n) was (18).

According to the following criteria, which were confirmed by clinical and radiographic examinations, eighteen partially edentulous subjects from the outpatient clinic were chosen to participate in this study: Patients had lower Kennedy class II edentulous span with a pier second premolar abutment opposing dentulous or partially dentulous maxillary arch, Patients had adequate bone volume at the modification space anterior to the isolated abutment to receive a standard size implant, patients exhibiting mutually protected occlusion. The remaining teeth have sufficient bony support, no mobility, and no periodontal disease, and exhibit cusp to marginal ridge occlusal arrangement. We excluded the following patients: patients having edentulous space opposite to the prospective implant site, patients exhibiting a parafunctional behavior, temporomandibular joint, and neuromuscular disorders, smokers, radiotherapy or chemotherapy patients, or those with systemic diseases that affect osseointegration.

The patients' study casts were mounted on a fixed condylar path articulator using a provisionary centric relation record for; evaluating the occlusal relationship of the remaining teeth, detecting any teeth that may need to have their occlusal facets adjusted because they are over-erupted or tilted, evaluating the inter-arch distance at the posterior region, assessment of available crown height space at the prospective implant site and for evaluating of the ridge relationship. All the required occlusal equilibration was executed before commencing the restorative treatment phase.

All patients had their implants surgically installed under stringent aseptic guidelines and in compliance with the delayed loading protocol, and each implant was restored with a separate screw-retained metal-ceramic crown.

At the insertion appointment, and before implant-crown placement, an 8 µm shim stock was held intraorally using its forceps, the patient was instructed to occlude into the strip in the position for maximum intercuspation, and the ability to grasp the strip between opposing teeth on the contralateral side indicated the presence of occlusal contacts, then the implant abutment screw was tightened, and the crown was intraorally checked regarding the marginal fit, and esthetics including emergence profile, shape, shade, and embrasures. Free interproximal contact with the adjacent tooth was verified by the slight snap when dental floss passed the contact point.

The occlusion was assessed again by the shim stock, to recognize whether the patients could still grasp the strip between opposing teeth (indicating the absence of implant restoration occlusal interference), or not (indicating premature contact on the implant crown), in this instance, an articulating paper was used to locate the position of the occlusal interferences on the implant crown.

In the dental chair, patients were seated straight. Single-sided Mylar-based articulation paper strips (Accufilm, Parkell, Inc.Edgewood, NY, USA) were used. **(Fig.1)** The subjects firmly tapped their teeth together through the articulating paper five times in a row while it was held intraorally by its forceps. Each subject was instructed to tap through the articulation strips while attempting to produce their perceived maximum occlusal force.

Fig. (1): Accufilm articulating paper.

To precisely interpret the light and heavy contacts based on the size, intensity, or appearance characteristics of the paper marks (subjectively and by the same personnel), so that they can be compared later on with the T-scan evaluations, a skilled photographer used an intraoral mirror and a digital camera to take standardized intraoral photographs for articulating paper markings. All photographs were taken with a digital SLR camera (Canon, 5D mark IV, Canon Inc, USA). A ring flash provided a consistent light source, the camera was used in the manual mode, with a fixed focal length of 100 mm, an aperture of F 29, and a shutter speed of 1/125 second.

The dental chair was always positioned maximum vertically down and consistently upright, and the camera was mounted on a tripod 100 cm from an intraoral mirror placed parallel to the maxillary teeth. This process standardized the photographic technique used on all subjects by repeatedly aligning the photographic mirror with the camera. [9] These images were kept to be compared at a later stage to the occlusal force data from the same subject's T-scan III multi-bite recordings.

Before starting the occlusion modifications, the occlusion was reassessed by an operator who is skilled in using the T-Scan III computerized occlusal analysis system (Tekscan Inc., South Boston, MA, USA), and who was blinded about the results of the articulating paper markings. **(Fig.2)** The recording sensor was placed intraorally between the dental arches to capture the real-time occlusal force and time-sequence data. The patients were instructed to bite down on the recording sensor as hard as they could for one to two seconds, three times through this process. The closure with the greatest occlusal force was chosen for the analysis.

Fig. (2): T-Scan III computerized occlusal analysis.

As soon as the recording was completed, the real-time window became a 2-D movie window, which around the mid-sagittal plane, was divided into two equal-colored boxes; one red for the right side and one green for the left side to illustrate the differences in the biting force intensities on the two sides. For the current movie, additional windows that automatically opened were the Graph, the Graph Zoom, and the 3-D movie window. The Graph and Graph Zoom windows contained color-coded “traces” representing; the forces applied, the distribution of the forces along the arch, the teeth under heavy contact, and the premature contacts inside each of the colored boxes in the 2-D movie window.

To estimate subjectively the degree of compatibility or deviation between the two evaluation methods, the acquired occlusal point and force data recordings were compared with the obtained digital photographs of the corresponding articulating paper markings of the same subject. This was done by one blinded clinician who compared the most obvious paper markings to the number of red or orange columns in the corresponding 3D view graph window of T-scan bite recordings. **(Fig.3)**

Finally, and according to the IPO concept, occlusal prematurity was addressed in static and dynamic movements based solely on articulating paper analysis. The implant crown's occlusal interferences were located using the articulating paper. Fine and extra-fine diamond burs were used to remove any early contact. A 19 µm articulating paper was then used for initial adjustment of occlusion under light biting force, to obtain the clinically recognized “light contact”, the achieved light contact was confirmed by using the shim stock, it was held intraorally using its forceps, the patient was instructed to lightly occlude into the strip, the ability to grasp the strip between opposing adjacent and contralateral teeth while easily withdrawn at the site of implant crown verified adequate occlusal refinement.

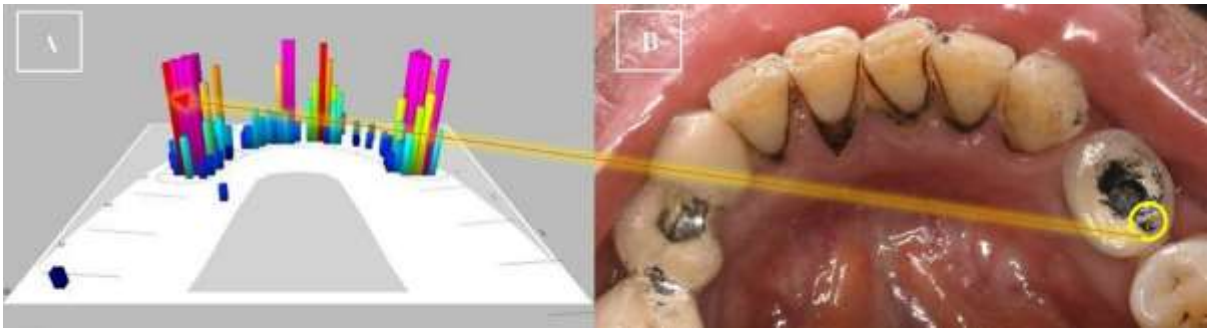


Fig. (3): Side-by-side orientation for matching force % and articulating paper marks A: 3-D view of T-Scan recording indicating the percentage of applied force per tooth represented by colored columns, B: Intraoral photo showing articulating paper marks.

After adjusting with light bite force, the patient was told to tap his/her teeth through a new articulating paper strip with the most occlusal force. The goal of occlusion evaluation under heavy occlusal load was to make sure the contact points on the implant crown and adjacent teeth showed similar intensity. Again, the performed equilibration adequacy was verified by the similar “resistance feel” when pulling the Shim Stock out from opposing occluded teeth at the implant site and adjacent tooth. Finally, the implant crown's excursive contacts were removed.

This study included two phases of T-scan occlusal parameters measurement, including before articulating paper-guided crown adjustments, and immediately after adjustments. The following T-scan occlusal parameters were recorded for each subject and saved for future data analysis; the percentage of applied occlusal forces displayed on the implant crown (POFI) and contralateral teeth (POFT). The relative accuracy or inaccuracy of the articulating paper-guided occlusal equilibration was evaluated by comparing the after-adjustment recordings to the baseline recordings obtained before the adjustments. The changes in the percentage of force applied to the implant crowns, and contralateral teeth after performing the occlusal adjustments were calculated and tabulated for statistical analysis. After obtaining all data and whenever T-scan evaluation revealed the need for further occlusal adjustment, it certainly was performed.

The T-scan relative occlusal force distribution data and the counterpart image of the articulating paper marks were placed side by side for data analysis, and the frequency with which the largest, most noticeable observed paper marks could describe the most forceful contact (indicated by the red and orange columns in the T-Scan 3-D graph window) were assessed. It was deemed a "match" when the biggest and strongest paper mark revealed the highest relative force on the same tooth in that quadrant. It was deemed a "no-match" when the tooth with the largest paper mark did not exhibit the greatest force on that same tooth. The implant crown area was the main focus of this matching procedure. Following that, the "matches" and "no matches" were tabulated for statistical analysis to determine how frequently matches occurred in comparison to no matches.

A computerized file was created for each patient before and after occlusal equilibration including the tabulated baseline recordings of “matches” and “no matches”, and all the measured parameters (POFI, POFT).

The abutment and the crown were returned to the working model again and the restoration was returned to the lab for extraoral cementation and glazing. For each subject, the extraoral cemented intraorally screw-retained crown was fastened to the implant intraorally and tightened with the manual screw-driver, A peri-apical radiograph was obtained to verify the proper connection between the crown and the implant platform, once fit had been verified, it was tightened to the suggested torque value provided by the manufacturer (25 Ncm) using the compatible driver in conjunction with the calibrated torque wrench. A small Teflon plug was placed in the abutment channel, then the screw access hole was plugged with composite resin to match the shade.

All patients underwent identical procedures in the construction of removable partials. A gingivally approaching clasp (RPI) was used on the non-dentate side for the second premolar, and an occlusal rest or cingulum rest served as an indirect retainer on the intact side. The dentures were designed with a lingual bar as a major connector, and a double Aker clasp on the first and second molars on the dentate side. **(Fig.4)**

Fig. (4): Removable partial denture on cast.

For the RPD, the heavy premature occlusal contacts in the centric position had been spotted by the articulating paper and correlated to the T-scan bite recording force and time data. Corrective occlusal adjustments were performed by grinding the premature spots selectively from the cusp tips and the central fossae. The procedure was repeated until the occlusal force was nearly equilibrated as confirmed by the T-scan force and time data.

Patients were educated and instructed on how to maintain good oral, denture, and implant hygiene and were scheduled for follow-up visits.

Results

Numerical data were explored for normality by inspecting the data distribution and calculating the mean using Kolmogrov-Smirnov and Shapiro-Wilk tests. Data revealed parametric distribution thus it was represented as mean and standard deviation. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation NY, USA) Statistical version 25 for Windows.

Comparison between the percentage of force to the implant crown before and after occlusal adjustment by using articulating paper was carried out using paired-T test, while comparison between the percentage of force to the implant crown and contralateral side (Dentate side) was carried out using independent-T test. The probability level of **P<0.05** is considered statistically significant.

Table (1): Mean, standard division, and t-test of the percentage of force to the implant crown (POFI) and contralateral side (POFT) before and after occlusal adjustment

Side	Before occlusal adjustment	After occlusal adjustment	Test value[1]
	No. = 10	No. = 18	
	Mean SD	Mean SD	
Implant crown (POFI)	56.93± 0.69	51.40 ± 0.64	2.32
Dentate side (POFT)	43.50± 0.52	49.03± 0.55	6.53
Test value[2]	8.892	1.145	

The data obtained from Table (1) revealed that the mean value of the percentage of force to the implant crown POFI was **(56.93, and 51.40)** before and after occlusal adjustment respectively which was found to be statistically significant as a p-value **P<0.05**. Regarding the contralateral side (Dentate side) the mean value of the recorded POFT was **(43.50, 49.03)** before and after occlusal adjustment respectively which was found to be statistically significant **P<0.05.**

Comparing the POFI and POFT the data obtained from table (1) revealed a significant **P<0.05**greater amount for the implant side before occlusal adjustment, however after occlusal adjustment although the POFI was greater than the POFT, the difference was found to be statistically insignificant **P**> **0.05**

Although a greater difference was detected after occlusal adjustment, statistical analysis of the data revealed an insignificant difference.

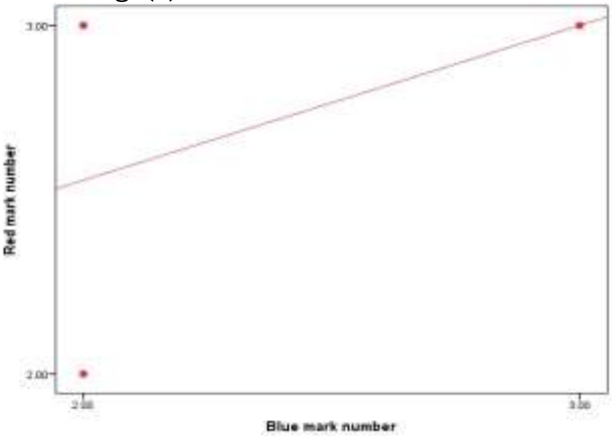
The concordance correlation coefficient measures variations in the linear relationship between two methods from the identity lines of two meaningful components: deviations in each measurement around the line (precision) and the distance between the identity line and the linear line (accuracy).

Table (2): Correlation between the red columns of the T-scan and articulating paper marks for premature contact.

	No.	Concordance correlation coefficient	95% CI
Red columns of T-scan& articulating paper marks	18	0.3662	-0.070 to 0.685

The data obtained from (table 2) According to Landis & Koch descriptions of estimates of the agreement are A coefficient of **0–0.20** slight agreement, 0.21–0.40 fair agreement, **0.41–0.60** moderate agreement, **0.61–0.80** substantial agreement, and **0.81–1** almost perfect agreement. The previous table shows that there was a statistically significant fair agreement between the red columns of the T scan representing premature contact and the blue mark with articulating paper with a concordance correlation coefficient of 0.366 (-0.070 – 0.685).

Fig. (5): the correlation between the



number of red columns of the T-scan and blue marks of articulating paper on the implant crown.

Discussion

Since the use of implant-supported single crowns has established itself as a reliable and preferred method to replace a single missing tooth instead of preparing the sound structure of two intact teeth to receive FPD, in the present study the modification space bound by the lone-standing abutment was restored by an independent implant-supported crown. [6, 21]

The two-stage surgical protocol was used because it has been proven that covering the implant with soft tissue and keeping it minimally loaded for three months lowers the risk of bacterial infection, prevents oral epithelium from migrating along the implant's body apically, gives the implant enough time to osseointegrate, and reduces the risks associated with loading the implant too soon during bone remodeling. [22] The crown was fabricated with an occlusal screw access hole, allowing for the crown to have a stock abutment on the laboratory model, taking the mechanical advantage of screw retention; moreover, the extraoral cementation technique permitted simple and efficient cement removal before intraoral placement. [23, 24]

Porcelain For implant-supported fixed partial dentures (ISFDPs), porcelain has taken over as the material of choice due to its satisfactory aesthetics, ease of occlusal adjustments, and wear resistance. Both the metal-ceramic and the all-ceramic occlusal materials could withstand loads. Metal-ceramic, however, can withstand loads of greater strength. [25]

The majority of dentists and dental schools still rely heavily on the articulating paper and the patient's "feel" feedback for implant-prosthetic occlusion establishment, even with the advent of the T-scan occlusal analyzer technology. [19] In this study, we sought to determine whether the goals of the IPO concept could be achieved solely by evaluating and equilibrating the occlusal contacts of a single implant restoration using the articulating paper. For this purpose, the T-Scan III system has been used as an objective method of post-adjustment evaluation of the implant-prosthetic occlusion because it provides a dynamic and comprehensive visual picture of the patient's occlusion route. [17, 18] In addition the articulating paper markings which were subjectively evaluated to represent the most intensive contacts were compared and correlated to T-scan recordings for occlusal points evaluation, this was an efficient way to accurately catch the changes and correlations of the occlusal force distributed on the implants and the natural teeth by contrasting the relative occlusal force values of those teeth in the T-scan recordings.

The null hypophysis for this study was thus accepted because further investigation using the T-scan occlusal analysis revealed that the implant-retained restoration's occlusion which had been modified solely based on articulating paper analysis was acceptable, and also because the paper-mark versus T-scan relative force data analysis depicted a positive correlation.

This study follows the same path as earlier ones that looked at and evaluated the articulating paper's accuracy in occlusal adjustment, particularly in the context of implant prosthetics, [9, 18,19, 26] as it is important to keep in mind that occlusion of a single implant restoration should be created to reduce the occlusal forces onto the implant and to guarantee even force distribution to the nearby natural teeth. [6]

The results of this study are somewhat consistent with those of earlier investigations that attempted to relate occlusal force to paper mark size. [9, 27, 28] The characteristics of paper mark appearance have repeatedly demonstrated that they do not accurately reflect the amount of occlusal force acting on a particular tooth.

In this study, statistical analysis revealed that the subjective interpretation of the articulating paper heavy contact marks based on their size and intensity is fairly correlated to the relative force data obtained from the T-scan occlusal analysis, **(fig.6)** this could be attributed to the fact that; instead of the applied occlusal force, the antagonistic tooth morphology is most likely what primarily determines the actual paper mark surface area. When a sharp surface is in opposition to a flat surface or comes into contact with other sharp surfaces, small traces may be left behind, conversely, large markings are likely to appear when large flat surfaces are facing each other (like in wear faceting areas), as a result of the wide surface contact that the opposing occlusal surfaces have. This explains why a small mark may have a much higher force related to it compared to a large mark, which may have a low force associated. These findings have important clinical ramifications because a clinician will frequently choose the wrong tooth to treat if they assume that the largest paper mark during an occlusal adjustment procedure represents the most occlusal force. [9]

The percentage of force applied to the implant crowns was significantly higher than that of the contralateral natural teeth before adjustments, which is considered occlusal overloading. Despite the low causative relationship between the paper markings and the applied forces, this study revealed a significant decrease in the POFI values after performing the occlusal adjustments, this is probably attributed to the proper implementation of tools and techniques, standardized selection for articulating paper thickness and die type, and to the systematic approach in using the most suitable articulating paper and shim stock foil to its fullest purpose. (6, 8)

In the current research, decreases in mean POFI values were accompanied by an increase in mean POFT values in the contralateral arch **(table1)**, and in the light of the fact that "force distribution should be equal bilaterally and maximized on adjacent teeth", (6) this finding is affirmative of the adequacy of the performed occlusal adjustments and achievement of equitable bilateral force distribution, which validate the quiet effectiveness and undermine the oppressive criticism of using articulating paper in such simple cases, this is of clinical significance because the longer chair time needed to obtain a high-quality T-Scan recording for carrying out a computer-driven occlusal adjustment procedure is laborious and viewed as a challenge by many clinicians. The T-scan learning curve entails selecting the proper sensitivity settings, orally guiding the patient through the needed mandibular movements with the sensor positioned between their teeth, and observing the screen to track the center of force trajectory as it moves around the T-Scan dental arch during the patient data acquisition, which gives clinicians the impression that using the T-Scan on patients is time-consuming, technique sensitive and is not that cost-effective, consequently, they still prefer articulating papers in the clinical setting. (13, 19, 29)

Although the increase in mean POFT values, the changes weren't statistically significant, this may be due to the resiliency of the periodontal ligaments which permit tooth movement when patients apply heavy contact. Natural teeth typically move 25 to 100 µm vertically, whereas dental implants typically move 3 to 5 µm axially, which could be enough to fog the resultant occlusal changes for the natural teeth. (5)

Lastly, it's worth mentioning that the T-scan not only records the instantaneous occlusal contact, including the position, intensity, and distribution in the chewing cycle to the nearest 0.01 seconds dynamically but also accurately depicts the distribution and changes in the occlusal contact for each tooth and dental arch. The T-scan's center of occlusal force (COF) trajectory can also be used to help in identifying how the balanced occlusal force changes dynamically. This permits a quantitative, impartial, and trustworthy analysis of "dynamic" occlusion, so its use is highly recommended in wider prosthetic rehabilitation. (12, 13)

Conclusion:

Articulating paper-driven occlusal corrections, in its best ways is not evidence-based, and at most is highly error-susceptible, however, for clinical correlation, occlusal accuracy in such cases (single implant-retained crowns) will not suffer if more readily feasible and simpler ways are employed to guide occlusal equilibration.

Conflict of Interest:

The authors disclose they have no competing interests.

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Ethics:

The ethical committee of the faculty of dentistry- Ain Shams University gave its approval to this study protocol on 16/11/2022, approval number: (FDASU.RecIR112230)

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