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COMPARISON OF ARTICULATING PAPER MARKINGS AND T SCAN RECORDINGS FOR OCCLUSAL POINTS EVALUATION AMONG NORMAL DENTULOUS POPULATION

Type of manuscript: original study
Running title: comparison of articulating paper markings and T scan recordings for occlusal points evaluation among normal dentulous population.

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ABSTRACT: -*Articulating paper is a diagnostic tool used in dentistry to highlight occlusal contacts and the distribution of occlusal forces. That is, it marks those points on the teeth where the teeth contact during biting and grinding. T-Scan is an objective assessment tool used to evaluate the occlusion of a patient. Unlike articulating paper, which can only determine location, T-Scan can identify both force and timing, two of the most fundamental parameters for measuring occlusion. The aim of this study is to compare the articulating paper markings and T scan recordings for occlusal points evaluation among normal dentulous populations. The articulating paper was placed intraorally and the subject was asked to clench their teeth firmly on the articulation paper. Standardized photographs were taken using intraoral mirror to compare the markings with those T Scan III multi-bite recordings at a later stage. The subjects were asked to occlude into and through the recording sensor and hold their teeth firmly intercepted together for 1–2 s The procedure was repeated thrice and the average of three recordings was taken. A questionnaire was then prepared on the comparison of both the above and circulated among dental practitioners and the results were statistically analysed. Close to 90% use articulating paper post FPD insertion whereas only 36% for post orthodontic procedures. Close to 66% of them had doubts on how to use the articulating paper to its fullest purpose and also not clear about the thickness of the same. Some felt red is thicker than blue or a certain colour is for static occlusion and other for movements. Many of them were able to correlate between articulating paper and the T scan contact points but couldn't accurately correlate the light and the heavy contacts, difficulties faced were patient cooperation, salivary contamination, tears. Many felt use of TScan was advantageous, but for clinical correlation, dentists prefer articulating paper. Area to be emphasised is the post orthodontic corrections using articulating paper which, in the present study, is not prevalent.*

Key words: *Articulating paper, T scan, occlusion, static, markings.*

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1. INTRODUCTION: -

Over the years, occlusal analysis has been a matter of guesswork. Occlusal indicators are widely used in dental treatment to measure tooth contacts that occur during occlusion (Msd et al., 2017). They are important tools in locating interference and refining occlusal contacts during prosthodontic rehabilitation (Saraçoğlu and Özpinar, 2002).

Aids such as articulating paper, waxes, and pressure-indicating paste are used when a dentist has to assess and balance the occlusal forces (Msd et al., 2020). The accurate measurement of tooth contacts can provide valuable information for diagnostic, treatment, or prognostic purposes. Hence, the accuracy of these indicators is essential for the establishment of occlusal harmony (Maness and Podoloff, 1989).

Occlusal indicators can be broadly divided into two categories based on their measurement capacity: qualitative and quantitative indicators (Beninati and Katona, 2019). Qualitative indicators, such as the articulating paper and articulating silk, are limited in measurement to only the location and number of tooth contacts (Ciancaglini et al., 2002); these are the most commonly used indicators because of their low cost and ease of application. Quantitative indicators, on the other hand, include electro-optic and resistive techniques such as the T-Scan pressure measurement system; these indicators have the added capability of measuring the time and force characteristics of tooth contacts, but they are more expensive (Jeong et al., 2020).

It has been advocated in textbooks on occlusion (Okeson, 1998) that the articulating paper mark area is a representative of the load contained within the mark. While using the articulating paper, we tend to assume that a vivid occlusal contact is the location where a large occlusal force has been applied (Okeson, 1998; Attanasio, 2003) The articulating paper mark appearance describes that large and dark marks indicate heavy load, whereas smaller and light marks indicate light loads (Weinberg, 1964). Additionally, the presence of many similar-sized marks spread around the contacting arches is purported to indicate the equal occlusal contact intensity, evenness, and simultaneity (Carey et al., 2007). However, limited literature exists to clinically correlate and confirm these findings. By employing articulating paper as a force measurement device, we, as clinicians, miss properly seeing the occlusal force, occlusal contact intensity, evenness, and simultaneity (Reddy, Kumar and Grandhi, 2004).

The ultimate goal is optimal achievement of functional occlusal forces and maximum intercuspation. The patient's teeth should be restored in such a manner that they are able to take up full functional load during mastication of food (Qadeer et al., 2012). The occlusal tactile sensibility for natural teeth can be as low as 8–10 μm (Cohen-Levy and Cohen, 2011). Patients may be able to feel occlusal discrepancies of that dimension when the teeth are restored. corrective adjustments are made by selectively grinding the marks to obtain occlusal stability, multiple contacts throughout the arches that exhibit simultaneity and reduce stress on the occlusal contacts and the periodontium (Farnum, 2004) Shimstock foil in combination with articulating paper markings have been advocated in the determination of occlusal tooth contacts that require adjustments (Li et al., 2017) Because the shimstock foil does not mark the selected teeth, the articulating paper markings are the primary guide for the operator when selecting which contacts require adjustment. In textbooks of occlusion it has been advocated that marked area is a representative of the load contained within the mark (Tanoue et al., 2019).

The T-Scan computerized occlusal analysis system (Tekscan Inc., South Boston, MA USA) overcomes the known limitations of articulating paper. (14) It quantifies and displays relative occlusal force information, so the clinician can minimize repeated errors of incorrect occlusal contact selection that often occur from relying solely on the combination of dental articulating paper and patient feel. T-Scan can help ensure that high quality and complete occlusal end results are

predictably obtained from clinical occlusal treatment.(14)The T-Scan determines the contact time sequencing and the percentage of relative occlusal force between numerous occlusal contacts and then displays them for all dynamic analysis (Cartagena et al., 2008). This enables the clinician to better identify many interfering contacts that are not readily identified by articulation paper markings (Garcia et al., 1997). Due to T-Scan system improvements made over the past 25 years, we are able to treat different occlusal problems successfully and provide patients with predictable high quality occlusal treatment end results which were not possible previously (García et al., 2008).

Thus, it is important to evaluate the occlusal force distribution and functional load in dentulous patients using computerized occlusal force evaluation systems (T-Scan) as compared to conventional methods of articulating paper (Tanaka, Tatsuta and Kawazoe, 2005). This study aims on the basis of registration of occlusal contacts via articulating paper and T-Scan system to evaluate the advantages and disadvantages of both methods in occlusal diagnosis of normal dentulous population.

2. MATERIALS AND METHODS: -

Materials Used:

We used Bausch 40-µm microthin articulating papers and ultrathin T-Scan II sensor (.004 inch, 0.1 mm). The articulating paper was tear resistant and coated with liquid colors on both sides. The special color coating with liquid colors consists of many color-filled microcapsules. Even the slightest masticatory pressure can cause the capsules to burst and, thus, release the distinctly visible color. The T-Scan system comprises a sensor, handle and cable, system unit, and software that detect patients' occlusal forces. The handle's attached USB cable is then connected directly to the computer via the USB port.

Methodology:

The articulating paper was placed intraorally and the subject was asked to clench their teeth firmly on the articulation paper. Standardized photographs were taken using intraoral mirror to compare the markings with those T Scan II multi-bite recordings at a later stage.The subjects were asked to occlude into and through the recording sensor and hold their teeth firmly intercuspated together for 1–2 s The procedure was repeated thrice and the average of three recordings was taken. A questionnaire was then prepared on the comparison of both the above and circulated among dental practitioners and the results were statistically analysed using the SPSS (statistical package for social sciences) by IBM.

Figure 1- markings obtained on light occlusion using the blue colour articulating paper.

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Figure 2- markings obtained on light occlusion using the blue and red colour articulating paper

Figure 3- markings obtained on heavy occlusion using the blue colour articulating paper

Figure 4- markings obtained on heavy occlusion using the blue and red colour articulating paper

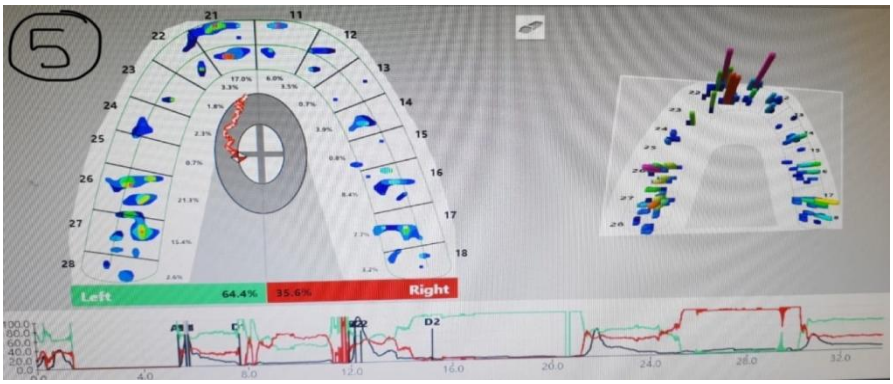

Figure 5- T scan recordings of light occlusion

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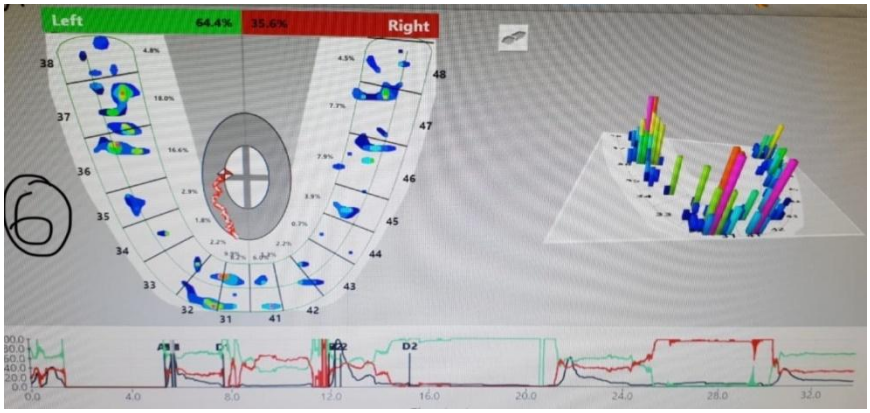

Figure 6- T scan recordings of light occlusion with movements.

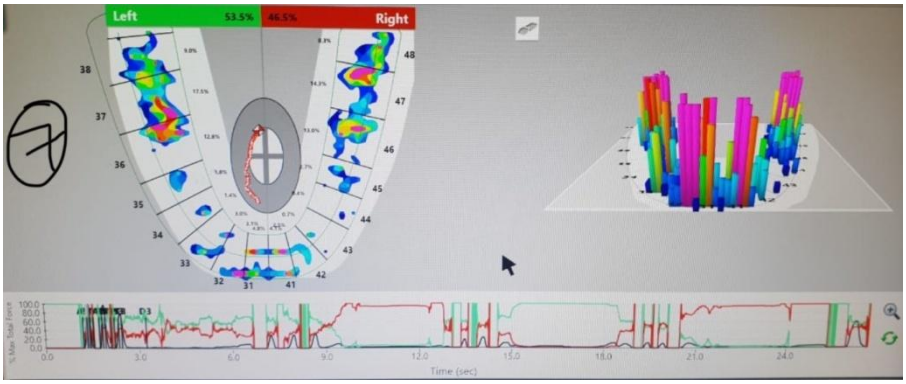

Figure 7- T scan recordings of heavy occlusion

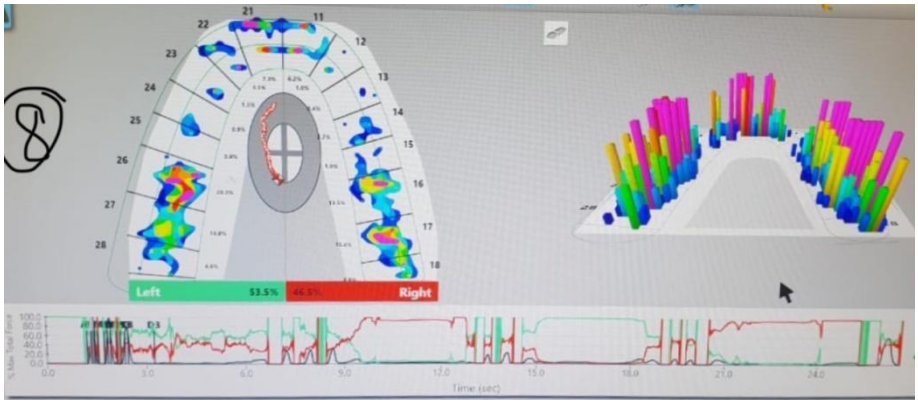

Figure 8- T scan recordings of heavy occlusion with movements

3. RESULTS AND DISCUSSION:

Close to 90% use articulating paper post FPD insertion whereas only 36% for post orthodontic procedures [Figure 10]. Close to 66% of them didn't know when and where to use the articulating paper and also the thickness of the same. Close to 56% of the participants used articulating paper after orthodontic corrections [Figure 11]. Close to 76% of them say that they use occlusal points evaluation during maxillofacial trauma [Figure 12]. Most of the dental practitioners were not aware of the exact thickness of the articulating paper that they are using and do not know the exact purpose of having blue and red colour in the articulating papers [Figure 13]. Further, many of the dental practitioners, about 57% of them, think

that conventional straight ones are better and easier to use when compared to the U shaped articulating papers while the remaining felt Horse shoe shaped articulating papers are more favourable [Figure 14]. About 91% of them feel that the use of T scan is better than articulating papers as it has better accuracy in case of occlusal points evaluation [Figure 15]. Further, the association between gender and the responses by the participants if T scan is advantageous over articulating paper. Majority of both Males and Females found T scan advantageous over articulating paper with p value > 0/05 statistically not significant (p=0.947) [Figure 16]. Some participants felt red is thicker than blue or a certain colour is for static occlusion and other for movements. Many of them were able to correlate between articulating paper and the T scan contact points but couldn't accurately correlate the light and the heavy contacts, difficulties faced were patient cooperation, salivary contamination, articulating paper tears etc. Many felt T scan is advantageous over articulating paper while some felt selective grinding is easier in articulating paper.

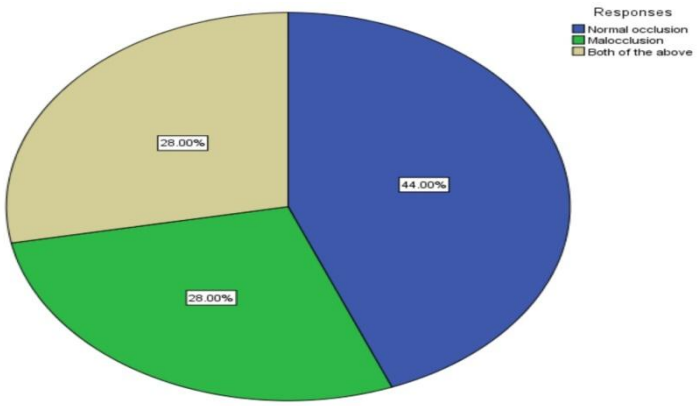

Figure 9- Pie chart representing the participants choosing the appropriate occlusion having premature contacts. Blue colour denotes normal occlusion, green colour denotes malocclusion and grey colour denotes both the above. Majority of the population, about 44% chose Normal occlusion, followed by 28% of the population who chose Malocclusion and both of the above.

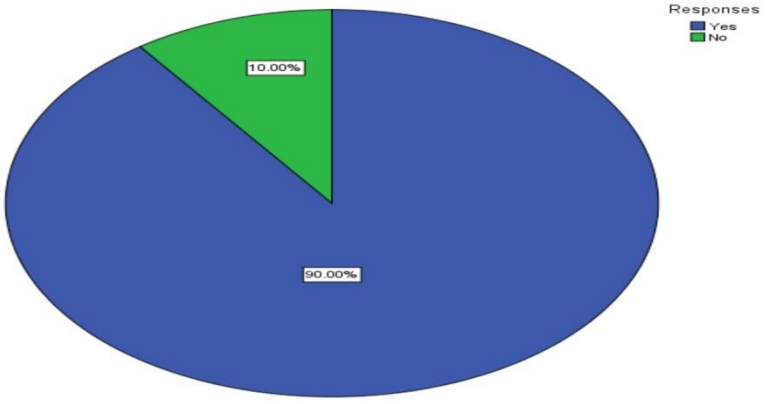

Figure 10- Pie chart representing the use of articulating paper post fixed dental prosthesis among the sample size. Blue colour denotes yes and green colour denotes no. Majority of the population, close to 90% used articulating paper after a fixed dental prosthesis.

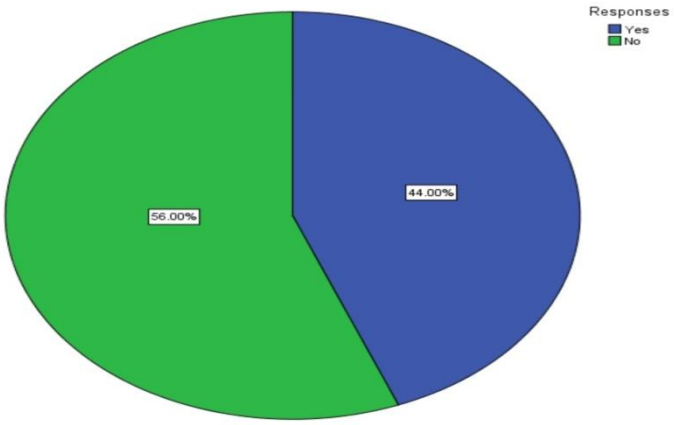

Figure 11- Pie chart representing the use of articulating paper post orthodontic corrections among the sample size. Blue colour denotes yes and green colour denotes no. Close to 56% of the participants used articulating paper after orthodontic corrections.

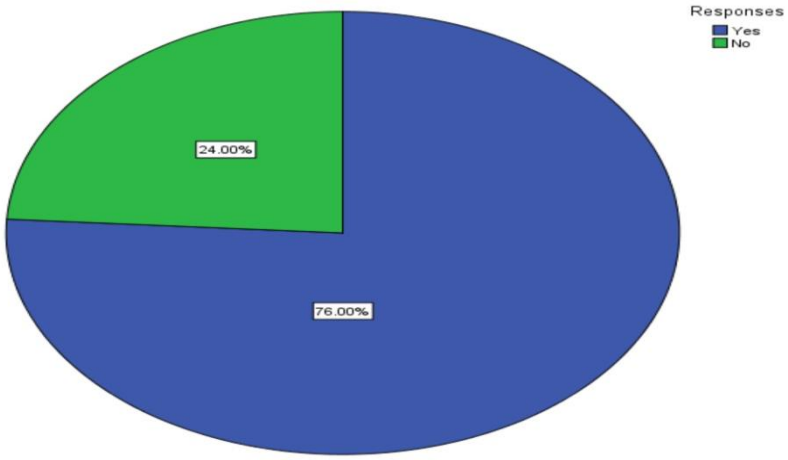

Figure 12- Pie chart representing the use of articulating paper in conditions such as maxillofacial or dental trauma among the sample size. Blue colour denotes yes and green colour denotes no. Close to 76% of the participants used articulating paper when the patients reported with maxillofacial or dental trauma.

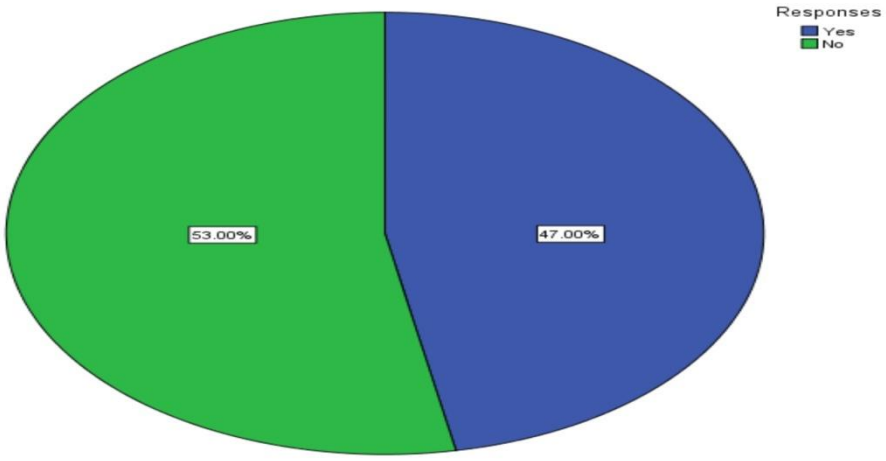

Figure 13- Pie chart representing the use of red and blue coloured articulating papers among the sample size. Blue colour denotes yes and green colour denotes no. About 53% of the participants were not aware of the use of red and blue coloured articulating papers.

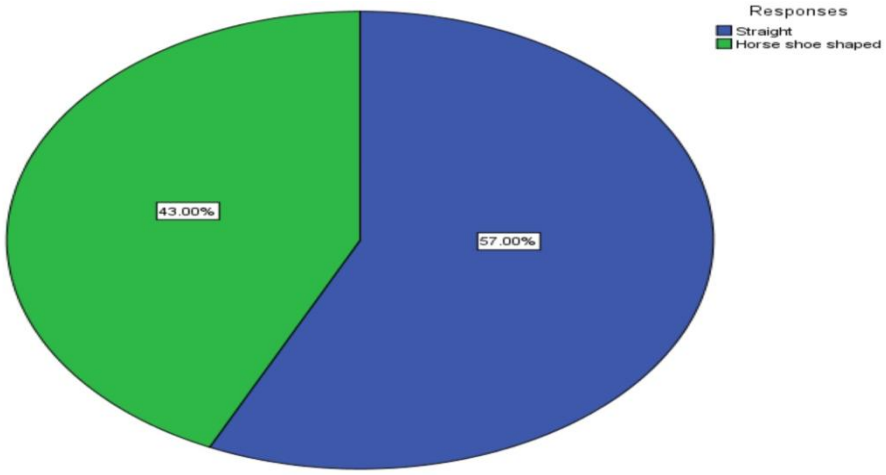

Figure 14- Pie chart representing use of the most favourable shape of articulating paper among the sample size. Blue colour denotes straight and green colour denotes horse shoe shaped articulating papers. About 57% of the participants preferred straight articulating papers over horse shoe shaped articulating papers.

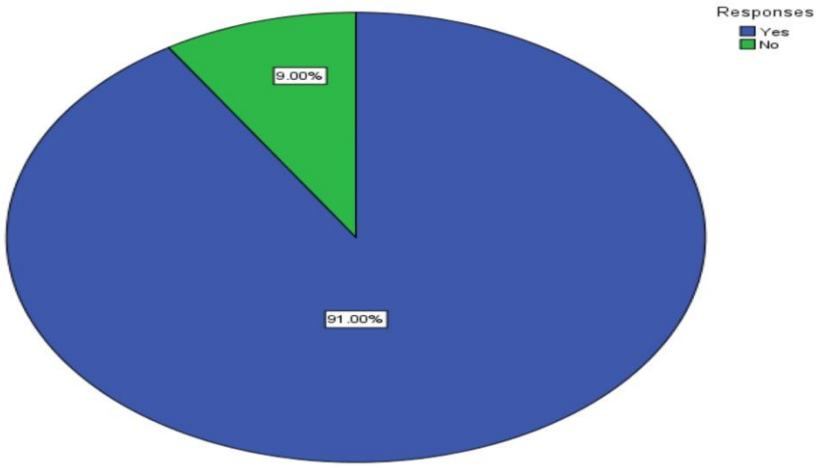

Figure 15- Pie chart representing the comparison of T scan and articulating paper for better occlusal evaluation among the sample size. Blue colour denotes yes and green colour denotes no. Majority of the participants, about 91% found T scan more favourable when compared to the conventional articulating paper.

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Figure 16- Bar graph depicting the association between gender and the responses by the participants if T scan is advantageous over articulating paper. Blue colour denotes males and green colour denotes females. Majority of both Males and Females found T scan advantageous over articulating paper with p value > 0/05 statistically not significant (p=0.947).

Articulating papers and occlusion test materials are tools used in daily prosthodontic and restorative procedures that aid the clinicians in the evaluation of adjacent and opposing natural and/or artificial tooth contacts. Registration with articulating paper visualizes cumulative pictures of the contacts in Centric occlusion and interceptive contacts without being able to distinguish them in size and time of onset. Computerized occlusal analysis objectively and quantitatively determines interceptive contacts and distinguishes them from contacts in MIP and gives real meaning to the terms "strong" and "light contacts" (Trpevska et al., 2014). The clinical problem when using the articulating paper for the registration of occlusal relationships is that based on the size and intensity of staining it was assessed whether a contact is “dense” or “light”. It is considered that “those parts of the occlusal surface which are pressed together” in CO with the antagonist are “the dense” contacts. On the contrary - those which are “in a lightweight contact with the antagonist” are the “light” contacts (Lee, 2013). According to the teaching of Prosthetic Dentistry in the country “the dense contacts” with indicator paper are stained “intensively” and “the light are slightly marked.”

However, in many cases the relationship between the size of the contact and its force content is reversed. Computer analysis leads us to the conclusion that in daily practice in our country dentists probably read incorrectly the size of markings from the indicator paper, and interpret them reversely. Clinical occlusal analysis should be based on the understanding that the broad large contact means low pressure, whereas light, although seemed a little indication of the paper represents a high pressure which computerized occlusal analysis shows as a strong contact (Dmd, Kerstein and D, 2020). Therefore, registration with articulating paper may serve as orientation about the location of contacts in centric occlusion (Bozhkova, 2020).

Results obtained in our study shows that the predominant population of dental practitioners prefer T scan over articulating paper markings owing to its accuracy. A study by Wang et al in 2011 revealed that the size of the articulation paper mark is an unreliable indicator of applied occlusal force, to guide treatment occlusal adjustments and it can be just used to find out the high points of occlusion (Wang et al., 2011). Further, A study by Bozhkova et al in 2016 revealed that the T-SCAN system provides the only accurate way to determine and evaluate the time sequence and force of occlusal

contacts by converting the qualitative data into quantitative and displaying them digitally (Bozhkova, 2016). This is in concordance with the general opinion of the dental practitioners in our study.

Strength of this study includes assessment of knowledge among the dental practitioners regarding the conventional articulating paper markings and computerised analysis such as T scan recordings. Further, the information provided in this article may aid clinicians and researchers to better select the most appropriate materials for the evaluation of static and dynamic occlusion. Limitations of this study include assessment of predominantly South Indian population and the Geographic locations and trends not being assessed.

4. CONCLUSION:

Many dental experts felt use of T scan was advantageous, but for clinical correlation, dentists prefer articulating paper. The occlusal markings using articulating paper were identifed better among dentist for premature contacts. Occlusal contacts were evaluated post prosthetic treatment but post orthodontic corrections use of articulating paper or T scan was comparatively less.

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CONFLICT OF INTERESTS:

None declared.

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