Occlusal Indicators: A Key To Achieving Stomatognathic System Harmony During Prosthodontic And Restorative Treatments – A Literature Review

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ABSTRACT

Occlusion is the fundamental concern of prosthetic and restorative dentistry. Occlusal discrepancies are one of the deleterious functional problems perceived after the treatment of the prosthesis or restorations. The study aimed to identify occlusal interferences in order to refine the occlusal contacts, by the use of occlusal indicators. It reviews and discusses the various occlusal indicators available for the correction of occlusal discrepancies in both fixed and removable prosthesis. The study proved that the functioning capacity of the indicators in terms of principle, reliability, accuracy, and method vary based on their varied characteristics. Additionally, it revealed that the oral environment, physical properties, and the elucidation of the clinicians regarding the indicator's readings also impact their functioning ability. It illuminated that it is not only concerned with the scrutinizing the occlusion but also includes the clinician's ability to record, store, and transfer the data for the achievement of the stomatognathic system harmony.

Key words: Indicators, Pain, Stomatognathic System, Temporomandibular Joint, Occlusion.

Introduction

Occlusion is defined as ''the static relationship between the incising or masticating surfaces of the maxillary or mandibular teeth or tooth analogues''.[1, 2] Even a micron of occlusal interference can trigger severe risk. To evade any pain or discomfort, the patient will apparently avoid biting the new dental prostheses or restoration. This affects the physiological position of the lower jaw leading to an unsound position.[3] In the stomatognathic system, the mandible acts as a balancing pole that is capable of affecting posture.[4] The balanced tension among the craniocervical bones, myofascial structures, dental occlusion, and neuroanatomical connections is important for maintaining the upright position of the head.[5]

Premature occlusal contacts in prostheses or dental restorations may lead to devastating alterations in the craniomandibular system. Articulating papers were traditionally used to identify any occlusal interferences.[6] Occlusal articulating media are made from paper, wafers, ribbon, foils, silks, silicon, irreversible hydrocolloid material, lacquer, sprays, and indicating waxes. Recently, films, chips, and computer analyzing systems have been added to the list.[7] General understanding of the science and properties of such materials will guide the dentists for their proper usage depending upon the circumstance observed.[8]

Occlusion is one of the most common fields of dentistry in which many overtreatments or faulty treatments have been performed.[9] Diagnosing occlusal discrepancies play a vital role in the planning and following the delivery of predictable functional and aesthetic restorations[10]. In addition, to maintain the dental, periodontal, articular, and muscular health, it is essential to detect adequate static and functional dynamic occlusion.[11]

For ideal occlusion, it is required to observe the simultaneous, bilateral, and homogeneous contact between the maxillary and mandibular teeth without any interferences or premature contact.[12] Understanding the patterns of teeth static and dynamic contact is required to achieve an accurate examination of occlusion in prosthodontic and restorative treatment and further to avoid occlusal discrepancy.[13,14] The presence of occlusal discrepancy may not be readily apparent when clinically examining; therefore, further occlusal analysis is required. Occlusal indicators play an important role in finding out occlusal problems.[15] Those areas that range from a contact to a gap of 0.5 mm between the occluding surfaces are recognized as near contacts; whereas, non-contacts are those areas with 0.5-2 mm space between the teeth.[7, 16]

Review Analysis

The occlusion indicators could be classified into qualitative and quantitative indicators. These indicators are considered as the most commonly occlusal registration materials as a result of their relatively lower initial cost and their application simplicity.[17, 18]

Articulating Paper

The natural perception of occlusal thickness usually ranges from 12.5 to 100 micrometer. Thick occlusal registration strip or one that a patient can perceive between the teeth has a disadvantage of indicating tooth contact between opposing teeth when no tooth contact exists. Any presence

of supra-contact should be removed below the threshold of appreciation.[18] Teeth are supposed to be dry before articulating the paper application to achieve better reading (figure 1 a, b). Its sensitivity is variable and decreases with the multiple uses.[19] Thin (12-µm or 40-µm) articulating paper is suggested for better readings.[20]

Articulating Silk Strips

The high tear-resistant natural silk has been considered as the best material for indicating the occlusal discrepancies.[12] It is based on the characteristics it constitutes of such as the soft texture, cusps, and fossae adaptability along with their accurate marking, which prevents the occurrence of pseudo contacts.[12] To sustain its moisture and effective marking abilities, silk is required to be stored in the fridge.

Photo-Occlusion Wafers

It is a thin photo plastic wafer applied on the lower teeth occlusal surface before instructing the patient to bite on it for 20 seconds. It is then examined under a polariscopic light. The use of photo-occlusion wafer technique is considered to be inconvenient.[3] A study compared the result of the photo-occlusion wafer with articulating papers, where the application of the technique was found to be difficult. [21]

Interocclusal Wax Record

Using this method, the dental waxes are softened under flame or in hot water, which are then moulded into shape as occlusal arches and put in patient's mouth onto the lower teeth arch.[22, 23] The patient closes the mouth over the wax in central position, the wax is then chilled with water and removed from the mouth. The thermoplastic features and dimensional instability of this material cause its deformation.[24] It is because it contains aluminium and copper particles, which constitute of the 2.5–22% rate of flow when the temperature is 37.50°C, which increases the distortion capability when removed from mouth.[18]

Articulating Foil Film

Foils are the thinnest material used as an indicator. The marking capacity of the foil is low when the pressure is low or the surface is glossy, which requires the patients to apply more pressure[25]. It is used for various purposes, both for intra-orally and for the technical work involved in the dental laboratory (figure 1c). Furthermore, it is used in a dry environment using special holders.[26] Foils could be considered as the thinnest occlusal indicator materials. They identify the contact points more accurately than articulating papers and silks. However, its marking accuracy might significantly be affected under lower occlusal pressure or on shiny surfaces. [27]

Metallic Shim Stock Film/Mylar Paper Strip

The shim stock film is color-coded on one side and has a metallic surface on the other side. It is generally indicated for the occlusal splint therapy in the laboratory for the accurate identification of the contacts on both soft and hard splints.[17] Metallic polyester shim stock-film contains colour coating and metallic 12-micron thick film. It has been recognized as a technique, which produces more accurate and reliable results as compared to the conventional shim stock films and articulating paper.[28]

High Spot Indicator

It is a liquid contact colour usually used in the laboratory to assess the proximal contacts of crowns, inlays, onlays, bridges, telescopic crowns, and clasps. This liquid is applied with a brush on the proximal surface of the coping to form a 3-micrometer thin layer. The stone dye is then placed in the cast, and upon removal, the proximal contact area is depicted as an area of the display through in the base material of the prosthesis.[17]

The Two-Phase Occlusion Indicator Method

In this technique, the consecutive use of the articulating paper and film spotlights the occlusal interference areas takes place in a precise and distinctive manner. Secondly, the articulating foil with a contrasting dye color is applied to mark the contact areas at the center, which was previously identified by the articulating paper marks. The central spot marked by the articulating foil was considered as the exact occlusal interference area that should be relieved.[17]

Carborundum Abrasive Paper

It is a stripping technique done by waterproof carborundum (silicon carbide) abrasive paper. It aims to maintain or modify the occlusal surface curvature and flatness of the posterior teeth. It is considered as a very time-effective method that permits the reduction of multiple teeth at the same moment. It is also cost-effective and readily available. One of its disadvantages is that it reduces both the buccal and lingual cusps when the teeth are in an end-to-end position similar to the working occlusion.[18]

Impression materials

- **Zinc oxide eugenol impression paste**

Zinc oxide eugenol impression paste is applied to the upper surface of the memory wafer. The polariscopic light is used because it allows the analysis of the location and intensity of occlusal contacts. Colour patterns, which are less than 10 micrometers apart (under the 10x magnification of the polariscope) might be considered as a single contact. This technique is called Novel photo-occlusion & colour marking technique.[21]

- **Alginate Impression Material Index**

Ingervall (1972) has proposed a technique by using alginate indices to identify the occlusal contact area on posterior teeth. In the technique, the alginate material is applied on the occlusal surface of the lower posterior teeth and canine. The impression materials are then carefully removed and evaluated against a source of light. The occlusal contact of any teeth is studied by the presence or absence of perforation on that site.[29]

- **Polyether Silicone Impression Bite, Silicon Putty, and Black Silicon**

Despite the cost and the impracticality of silicone impression materials (figure 1d) for the identification of the occlusal contact pattern, it is found to be very accurate and easy considering the testing and transferring for the articulation of the study models.[30,31] As other impression materials, perforations or translucent areas indicate the occlusal contacts.[32]

Transparent Acetate Sheet

Davies et al. (2005) proposed a clinical method termed as the occlusal sketch technique to record occlusal contacts[33]. This technique is less time consuming, inexpensive, and convenient to handle and can be used for casts occlusal verification.[25,34] To pinpoint the occlusal contacts and occlusal interference areas, the contact regions should trace onto each occlusal sketch after completing the occlusal record. The transparent occlusal sketches are then overlaid by a 1-mm^2 transparent grid to facilitate the comparison between 3 clinicians by comparing the X and Y coordinates for every occlusal contact in a particular region which is being considered.[33]

Occlusal Sprays

It is a commonly used colour indicator, which assesses the occlusal contacts and the fitting of the fixed dental prosthesis (figure 1e). It is applied at a distance of 3-5 cm onto the occlusal surface or to the fitting surface of the bridges or crowns. All premature contact points will be instantly seen when the fixed prosthesis seating was tried in a drier environment.[35] Sprays can also be used to assess the proximal contacts for the trial seating of crowns and bridges. It is convenient to handle and can easily be removed with water.[19]

Typewriter Ribbon

Ziebert and Donegan explained the use of typewriter ribbon for the identification of the supra contacts or occlusal interferences for occlusal adjustments. It helps in marking the interferences and also verifies the contacts using the 0.00l-inch shim stock.[31] The adjustment procedure was described by Schuyler[36]. It provides information that the M.U.D.L. rule is and the B.U.L.L rule is applied for the retruded position, and B.U.L.L. D.U.M.L. rule is used for assessing the protrusion and the B.U.L.L rule for the working movement. In order to maintain the centric stop on each tooth, the non-functioning interferences were eliminated.[3]

Selection of the Qualitative Indicators

There are various parameters for the selection of qualitative indicators such as thickness. Extreme thickness can encourage a false proprioceptive response that might affect the occlusion pattern and cause premature jaw deflection.[7] Adequate tensile strength is needed to prevent an early tear of the indicators as it may take place in some very thin strips. Marking ability is also important in the occlusal contacts, which require the colouring, staining, or marking agent bonding to the tooth. Articulating foils have been found to have the highest marking sensitivity values, followed by the most commonly used articulating paper. Teeth should be carefully dried prior to the use of all qualitative occlusal indicators.[17]

Quantitative Indicators

The proper occlusal contact time by definition indicates that a time of 0-second lapses between the first and last occlusal contact. Thus, all the contact points on the occluding surfaces should come in contact at the same moment during the mandibular closure.[37] One of the occlusal therapies' aims is to achieve this simultaneous smooth occlusal contact relationship without any deflection.[16]

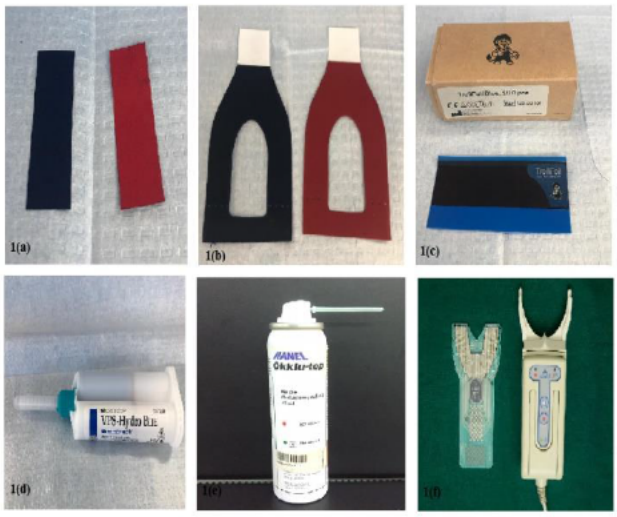

Figure 1: (a) Sectional double coloured articulating paper; (b) Full arch articulating paper; (c) Articulating foil; (d) Polyether silicon impression bite; (e) Occlusal spray; (f) T-scan recording sensor

Occlusal Sonography

"Dental Sound Checker" was produced in Japan in the mid-1980s by Watt. Its production took place to evaluate

occlusal contact sound patterns during closure to detect the possible occlusal disturbance.[38] Kifune et al.[39] calculated the duration of the occlusal sound in a subject before and after occlusal adjustment. A large amplitude, the long sound would be made by a forceful slow closure, and a soft rapid closure would make short low amplitude sound. Therefore, recorded documents of occlusal sound were of limited value unless the patients were trained to close their teeth with constant force and speed.

T Scan

T-scan is one of the newest and developing systems for quantitative occlusal analysis, which was introduced by Maness (figure 1f).[40,41] Later, in the mid-1980s, Tekscan developed T-Scan®, which was the first-ever grid-based sensor technology, particularly designed for occlusal analysis.[16,42] Furthermore, it can quantify any occlusal surface engagement. This analysis can be played back or forth by 0.01s or if in turbo mode by 0.03s increments, which can never be visualized by our eyes or any other method, which is currently available.[43,44]

The T-Scan computerized system can effectively locate the premature contacts, high contact points, areas of excessive occlusal load, and non-uniform load concentration.[17,41] T-Scan's recording sensor consistently reproduces 256 levels of varying occlusal force, so it can provide the accurate precision of force and time required for diagnostic along with the controls which must be established during treatment.[45] It also analyses the collected data, with the amount of load and time contact relationships, which is displayed by colour contour images. It also manages patient scan files through the use of an intuitive database.[46] The T-SCAN III system has been considered to be a very precise system to assess and analyze both the dental occlusion and articulation.[47, 48]

Application of T-SCAN

T-scan is applicable for fixed, removable, and implant prosthetics, TMD appliances, and direct and indirect occlusal equilibration. It also assesses and manages the abfraction, assists in periodontal management, differentiates diagnosis for dental pain associated with occlusion, orthodontics, locating painful teeth or premature occlusal contacts after multiple restorations, etc. T-scan is available in various versions -T scan I, T scan II, T scan III, T scan IV, T scan V, and the latest is VI. The data is obtained from T-scan can be analyzed in three ways;

1. It shows the duration and relative magnitude of all tooth contacts.
2. It identifies disproportional loading forces and transient impact forces acting on specific teeth.
3. It identifies active tooth contact occurring within the functional range of mandibular movement and the interaction between working and nonworking interferences.[16]

Limitations of the T-Scan System

Thinner occlusal indicator materials usually provide more reliable markings of the occlusal contact points than thicker ones. This might alter the dynamic and functional occlusion pattern and could disturb the activity of the muscles of mastication. Alteration of occlusion and the occluding pattern seems to happen with all other occlusal registration methods in different degrees, thus, such limitations are supposed to exist in the minds of the clinicians when they aim to restore tooth/teeth in occlusion confirmative or when they have to reorganize the approaches used.[7]

The T-scan sensor's sensitivity is negatively affected when the sensors are used more than once [49] and it may also be damaged due to sharp tooth cusp. This may also lead to the inaccurate recording of the occlusal contact or artifacts in the produced images. The occlusal interferences reproduced by the T-Scan system has been reported to be around 0.6mm in dimension. Additionally, changed occlusal contact data can be reproduced by the application of two different system modes, force and time analysis modes.[7]

Pressure Sensitive Films

It is a device used to identify the occlusal contact location and force by using digital sensitive film. Some studies show a reliable reading of this device when occlusal load measures on patient and study cast.[30,50] One of the main drawbacks of this device is its thickness, which might give a false reading for the posterior teeth compared to the anterior teeth and inhabit the closure in maximum intercuspation position.[51]

Virtual Dental Patient

Virtual technologies have been introduced to dentistry to provide digital education and training by simulating complex contexts and improving procedures that restrict traditional teaching and training methods, such as using mechanical articulator.[50] This is a new concept and was performed in a virtual three-dimensional dental patient, in which the data was collected from the scanned casts of the patient's teeth. This provides quantitative data that helps the assessment and evaluation of the masticatory function and detecting the occlusal discrepancies.[52,53]

Implications

The clinicians should assess the articulation of the teeth/prosthesis with respect to simultaneous contacts, biting time and biting force. The criteria for the accuracy of an interocclusal bite record were provided by Dawson[54]. The study showed that the bite record should not cause any movement of teeth or displacement of soft tissue. However, it must verify the accuracy of the interocclusal record in the mouth and should fit the dental casts as accurately as it fits the mouth. The recording materials have to be used only once, and teeth have to be dry during occlusal analysis.[54] Also, the thickness of articulating papers is 40 μ that is well above the thickness perception level of the patient.[17] Anderson et al. compared an articulating paper method against a Mylar paper method and found the latter to be more reliable.[3]

Millstein[25] compared occlusal contact marks made on acrylic resin casts with perforations, which occurred in a silicone interocclusal record by the photographic method and found out that the occlusal contact markings were specific for, and a product of, the occlusal indicator papers and does not represent the contact surfaces determined by the silicone interocclusal records.[3] Furthermore, Murray[3] suggested that the clinical recording and transfer of information using waxes have disadvantages relating to inaccuracy and problems of manipulation. Additionally, Maru et al. in his study highlighted that the wax heating in an ununiformed manner, inaccurate recording, and improper way of a record transfer to the laboratory may impact the record.[55]

Gazit et al. compared the results of the occlusal examination of 11 dental students by means of the photoelastic wafer and articulating paper. The results were transferred to a graphic occlusal scheme. None of the techniques were observed to be highly reproducible.[3] Good reproducibility studies with occlusal sonography have not been yet reported. However, this may be helpful for dentists to evaluate the occlusal fit of a newly fabricated single crown or loading of a new implant abutment.[38]

Considering the pressure-sensitive films, the study of Araki et al. can be considered which used pressure-sensitive films in 5 patients with TMD and evaluated the distribution and area of the tooth contacts and the total occlusal force. Also, its thickness disturbed the person's attempts to close into the intercuspal position.[3] T-Scan III effectively that checks occlusal balances, is a reliable tool to detect early contacts and very effective in full mouth rehabilitation cases.[56] It can also be used for guidance, which can guide the tooth contact locations requiring appropriate occlusal adjustments. Measurements reported with T-scan III along with the differences between subjective balance occlusion were observed with 54 participants that were divided into three groups: Group I was of participants with fixed dentures with prosthetic ceramic restorations. Group II was symptomatic participants with TMD. Group III was the control group of healthy participants with full arch dentition who completed a subjective questionnaire, which indicated the absence of locking, joint noise, jaw pain, and had subjects without a history of TMD.

T-Scan III system is a valuable and effective tool for occlusal adjustments and for establishing the desired occlusion pattern to avoid excessive loading and complications with restorations and implants, especially in full mouth rehabilitation or complex implant cases. This method decreases the subjective interpretation of occlusal analysis data and gives accurate registration of static and dynamic occlusal information.[54] The limitation of its usage is its thickness and sensitivity, which decrease when used more than once. The same results were achieved in the Saraçoğlu et al.[19] study which highlighted that the accuracy of the T-Scan system record declines by repeated measurements. However, the findings of Koos et al. contradict it, as it found no loss in the accuracy of the measurements after undergoing continuous measurements.[34] Despite it, the study observed it as the most reliable indicator of the interceptive contacts.[57]

DeLong used shim stock and transillumination to compare the occlusal contacts calculated from 3D virtual arch models and interocclusal records. In this method, no effect was observed in terms of the scanning holes and translucent regions in the record where the teeth contact as compared to the interocclusal record method. Hence, movements caused by interactions between the teeth when they are in contact are not recorded, unlike the interocclusal record method. This causes differences between the contacts calculated with the MIP and casts virtual models. This problem can be solved by the use of a dual-arch tray to capture the upper and lower occlusal anatomy and the MIP simultaneously.[58]

Conclusion

Accurate bite records have long been a concern in dentistry. Various materials are available such as qualitative materials like articulating paper, wax or impression materials wafers, ribbon, foils, silks, lacquer, sprays that are economical and easily available.[59] Moreover, the quantitative materials like Occlusal Sonography, Pressure-sensitive films, a T-Scan, and virtual technology that require minimal adjustment can be used to decrease the time required. The quantitative material increases a patient's confidence in the dentist and his team. However, every material has limitations; hence,

the decision to use either of these materials will depend upon the clinician's choice and skills, clinical situation, economics, and comfort of the patient.

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Conflict of Interest

The research has no conflict of interest and is not funded through any source.

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