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Prosthetic Occlusal Analyzers - A Comprehensive Review

Review Article

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Abstract

Any prosthetic rehabilitation definitely deals with occlusion. Occlusion provides the functional stability of the prosthesis and hence it must be checked and verfied. The occlusal analysers used to verify occlusion are varied and its use also differs. The idea of occlusion should be viewed in static or dynamic form and appropriate mix of use occlusal analysers will help in analysing occlusion better.

Keywords: Occlusal Analyser; Dyanmic Occlusion; Occlusion.

Introduction

Dental occlusion varies among individuals. Normal occlusal and articulation relations between the jaws ensures balanced distribution of the generated forces during mastication.[1] Any premature occlusal contacts and occlusal-articulating blockages cause occlusal traumas which induces changes in the tooth-supporting tissues, in the masticatory muscles and the temporomandibular joint.[2] Achieving correct physiological occlusion after full mouth rehabilitation is essential for the complex functioning of the stomatognathic system.[3] Often, a change in the vertical dimension of occlusion is required for rehabiltation.[4] Proper evaluation followed by definitive diagnosis is mandatory as the aetiology of severe occlusal tooth wear is multifactorial and variable.[4, 5] Careful assessment of the patients habits and medical history is essential for appropriate treatment planning.[6] According to Tiwari et al, the principles of treatment are universal and all the functional factors are interrelated. Thus, occlusal rehabilitation is a radical procedure and should be carried out in accordance with the dentist's choice of treatment based on his knowledge of various philosophies followed and clinical skills.[7] Rehabilitation requires verification at all stages from diagnosis to interim occlusion in temporaries to final prosthetic occlusion.[8] such occlusal verification can be carried out using occlusal analysers.

Occlusal Analysers

There are a variety of occlusal analysers used to register the occlusal-articulation relations. The occlusion indicators can be broadly divided as qualitative and quantitative indicators, the principal difference being that the quantitative indicators are capable of measuring the tooth contact events. Qualitative indicators: Articulating paper, Articulating silk, Articulating film, Metallic shim stock film, High spot indicator. Quantitative indicators: T-Scan occlusal analysis system, Virtual dental patient.[9]

Carborundum Stripping technique(1970)

The material being utilized was waterproof carborundum abrasive paper. It preserves or enhances the flatness of the posterior occlusal surfaces, takes less time, allows several teeth or a portion of a single tooth to be reduced at one time. It is an economical technique and is readily accessible. One of the drawwbacks is that when the teeth are in end-to-end as in working occlusion, reductions of both the buccal and lingual cusps will result.[10]

Inter-occlusal Wax Record

Wax has gained wide acceptance for the transfer of interocclusal records, but it is not easy to achieve full closure in wax and rarely

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registers precise incisal and occlusal teeth forms. It is easy and clinically flexible to use. But there are several drawbacks to being imprecise, unstable and inconsistent. Studies have shown that waxes contain particles of aluminium or copper that have flow rates of 2.5– 22% at 37.5°C. One major drawback is that on removal from the mouth, these are susceptible to distortion. The occlusal contacts were recorded by Enrich and Taicher (1981) and these records were examined in front of a light screen. To visualize and verify the exact location of each contact (supracontact, contact and near contact), each registration was placed on the diagnosed cast to visualise.[11]

Novel Photo-Occlusion & Color Marking Technique(1986)

The NPT was based upon the technique of photo-occlusion. Coltene paste was applied to the memory wafer's maxillary surface. Under the polariscope, this wafer was then examined and the location and intensity of occlusal contacts analysed. Color patterns less than 10 micrometer apart were counted as a single contact. [12]

Virtual Dental Patient(2002)

By simulating complex contexts and improving procedures that are traditionally limited, such as working with mechanical articulators, virtual technologies in dentistry are used to provide better education and training. This is a concept recently introduced in which the three-dimensional dental patient is compiled from the information scanned from the dentition casts of a patient. This provides quantitative data to aid in the evaluation of its chewing function and the identification of occlusal interference. It is possible to calculate valid occlusal contact from aligned virtual casts. The preferred contact calculation method utilizes virtual casts aligned with interocclusal virtual records.[13, 14]

Transparent Acetate Sheet

A clinical method called the occlusal sketch technique as a means of recording occlusal contact was described by Davies et al (2005). It consisted of a transparent sheet of acetate representing the occlusal aspects of the teeth in outline. The use of acetate in this manner facilitated viewing of the marked occlusal contacts from both sides. There are marked static and dynamic occlusal contacts. The contact anatomical regions were traced to each occlusal sketch after completing the occlusal record for each subject to define the locations of occlusal contacts. By comparing the x and y coordinates for each occlusal contact in a particular region, the occlusal sketches were overlaid with a 1-mm2 transparent grid to allow comparison between the 3 clinicians. The occlusal sketch appears to be a simple way of recording and subsequently incorporating the occlusion of patients into dental records. Furthermore, this technique was quick, inexpensive, and easy to perform. [15]

High Spot Indicator

It is a contact color, udes for testing the accurate fit of crowns, inlays, onlays, telescoping crowns and clasps, applied with a brush. Within seconds, the solvent evaporates, leaving a thin film 3µ thick. Each contact destroys the skin color precisely at the point of contact. The base material then shines through clearly and it is possible to easily detect high spots. It can also be used on highly polished occlusal surfaces such as gold or ceramic to test elevated spots. The food dye in the solvent is completely secure and can be easily removed with hot water or alcohol after use.[9]

Occlusal Sprays

It is a universal color indicator that tests the occlusal contacts and the exact fit of crowns and bridges. It is simple to handle and leaves a thin colored film that can be washed with water quickly, leaving no trace of residue. It is applied to the occlusal surface or within the bridge or crown at a distance of 3-5 cm. Both contact points will be instantly apparent when checking the occlusion or trial seating of the bridge or crown. The spray is intended for the marking of prosthetic contact points and crowns by means of a small, easy-to-dose colour film. The occlusion spray film thickness is just 6-8µ.[16]

Articulating silk

It consists of a color pigment micronized, embedded in an emulsion of wax-oil. Since it has a soft texture, during use, pseudo markings are not produced and are effective when used intraorally. However, when stain components are dried and contaminated by saliva, it loses its marking ability. Hence, its storage in a cool, closed environment is essential. It is highly suitable for use on highly polished surfaces, particularly ceramic and gold in lab models, where one strip can be used as many as ten times.[17]

Articulating film

The articulating film of Bausch Inc., Artifol, has only a thickness of 8 µ, which is far lower than the patient's thickness perception stage. It is composed of a 6 µ thick emulsion that is hydrophobic and contained inside a polyester film. It must be used in a dry setting using special holders. It is universally applicable to both intraoral and laboratory models.[18]

Metallic shim stock film

The shim stock film has a metallic surface on one side and the other side is colour coded. It is mainly indicated for use in the occlusal splint therapy in order to accurately mark the contacts on the soft splint in the laboratory. [19] A study by Gupta et al stated that shim stock exhibited superior accuracy and reliability as compared to the articulating paper. [20]

The two-phase occlusion indicator method

In this method, the sequential use of the articulating paper and the articulating film highlights the actual interference areas accurately and clearly. The articulating paper is initially used to mark the contacts represented as a clear central region surrounded by a peripheral rim of the dye. In the next step, the articulating foil of a contrasting colour is used to mark the contact spots in the center of the contact areas highlighted by the articulating paper markings previously. It is the central areas marked by the articulating foil that are the actual interferences and are to be eliminated.[21]

Articulating Paper

In dental practice, articulating paper has been established as the

most commonly used diagnostic tool to identify contact points between the maxillary and mandibular teeth.[22] The paper can readily highlight occlusal contacts, but cannot accurately quantify their intensity and measure the magnitude of the generated occlusal forces.[22, 23] The size of the mark area on the articulating paper is representative of how heavy the occlusal load is in that region. Various thicknesses are available ranging from 8µm to 200µm.[20]

According to Brizuela-Velasco et al, the central area of the registration with a lower chromatic intensity is the real occlusal contact and correlates with the results obtained using a thinner articulating paper.[24] However, Carey et al conducted a study which concluded that the size of an articulating paper mark may not be a reliable predictor of the actual load content within the occlusal contact.[25]

Saad et al state that the interpretation of the marks on the paper is subjective and therefore inaccurate because identical occlusal loads correspond to markings of different intensity. [26] This conclusion is supported by Millsterin et al and Basson et al. [27, 28] A polling study by Sutter et al confirmed that subjective interpretation of articulating paper markings is a very inaccurate way to choose forceful occlusal contacts for occlusal adjustment treatment. This is because dentists are unable to predictably choose high force contacts using their visual skills in combination with the non-scientific principles of subjective interpretation. [29]

Kerstein et al stated that subjective interpretation is an ineffective clinical method for determining the relative occlusal force content of tooth contacts. This longstanding method of visually observing articulating paper marks for occlusal contact force content should be replaced with a measurement-based, objective method. [30]

T-Scan

Maness in 1987 developed the T-SCAN system for computer occlusal analysis because it yields measurements in real time of occlusal forces recorded using the T-SCAN intraoral sensor.[31] In 1992, Lyons MF et al found in a clinical study evaluating the T-SCAN system for measurement of occlusal forces, that the system was unable to measure them accurately although it can still serve as a useful clinical tool.[32] In Bulgaria, Kalachev conducted a number of studies on the occlusal-articulation relation in intact dentition during articulation with T-SCAN II elucidating the relationship between occlusal load and periodontal stress.[33]

The first generation (G1) sensor developed in 1987 has undergone many changes in its design and improvement of its registration capacity based on a number of clinical studies. The last generation sensor developed by the same company is the high definition sensor which is far more sensitive and thinner(105µ) than the previous sensors.[34] Two sizes of this sensor are now available on the market: a small size accommodating dental arches up to 58 mm wide, and a large one that can accommodate up to a 66-mm-wide dental arch.[35]

The original design of the T-SCAN system has been repeatedly modified and improved both in the software and hardware until the present day version of the system - T-Scan III. The software uses graphical interface. The programme processes the data and shows them in full-colour 3D or 2D graphics. In the 2D graphics the generated occlusal contacts are visualised as contours or cellular images on the dental arch. There is an optional feature that allows the left and right sides to be shown in different colour codes .(green on the left and red on the right) with the respective occlusal forces displayed below. The dentition can also be divided in anterior and posterior halves giving as a result 4 segments to analyse. In the 3D graphics, the registered contacts are visualised as columns of different color and height quantifying the intensity of the forces generated on occlusion. The magnitude of occlusal load is colour coded the maximum being shown in pink and the minimum force in blue.[36]

T-SCAN III analyses the order of the occlusal contacts while simultaneously measuring the force percentage changes of those same contacts, from the moment the teeth first begin making occlusal contact all the way through to centric intercuspation. It shows the abnormal forces leading to trauma or pain in every tooth in the dental arch. This helps to balance the forces on both sides of the dentition. Kerstein RB et al. consider the T-SCAN III system to be a highly accurate technique to study and analyse the occlusal and articulation relations.[37] Koos supports the view that the system has certain advantages in terms of accuracy, reproducibility and visualisation of the dental arches.[38]

Afrashtehfar and Qadeer have reported that the computerized occlusal analysis system provides quantifiable force and time variance in a real-time window from the initial tooth contact to the maximum intercuspation, therefore, providing valuable information.[39] Bozhkova reported that the T-Scan system provides a very accurate way of determining and evaluating the time sequence and force magnitude of occlusal contacts by converting qualitative data into quantitative parameters and displaying them digitally. The system is a useful clinical method that eliminates a biased, subjective evaluation of the occlusal and articulating relations on the part of an operator.[40] Trepevska et al in 2014 stated that Tscan shows great promise to determine occlusion in orthodontics.[41] Agbaje et al in 2017 also stated that T-scan can be used pre and post operatively in cases that require orthognathic surgery.[42]

T-Scan Versus Articulating Paper

When articulating paper and T-scan were compared Gokhem et al in 2012 stated that articulating paper was more sensitive than T-scan. However, Majithia et al in 2014 conducted a study on prosthodontic rehabilitation of treated maxillofacial trauma cases by evaluating occlusal force distribution. They took into consideration the two parameters. Firstly the largest articulating paper mark (photographed) and secondly the T scan of the same patient. Comparison was made between the largest articulating paper mark and highest force tooth in the quadrant using T Scan. The matches and no matches were then tabulated for statistical analysis assessing the frequency of the matches to the no matches. They concluded that T-scan was more reliable than articulating paper.[43]

Reddy et al conducted an invitro study and concluded that the size of an articulating paper mark may not be a reliable predictor of the actual load content within the occlusal contact, whereas a T-

Scan provides more predictable results of the actual load content within the occlusal contact.[44]

de Prado et al checked a new technique for alignment between T-Scan and 3D digital casts. They concluded that any alignment following this method there will be an 81.82% probability of a coincidence ratio between 70.83% and 94.44%. But, since this was the first study to evaluate this method, they recommended that the practice of combining both T-Scan and articulating paper methods would obtain the best results possible. Articulating paper will bring more accuracy to the positioning of occlusal contacts while the T-Scan will show dynamic data and changes in the contacts during the entire bite, which would be impossible to determine if only using an articulating paper.[45]

Luo et al conducted a study to analyze changes in occlusal force distribution and occlusal contact in posterior partial fixed implant-supported prostheses over time, and to provide reference for the precise occlusion design, adjustment and maintenance of implant prostheses occlusal examinations were taken with the articulating papers and T-Scan III. The occlusion time and relative occlusal forces of implant prostheses, mesial adjacent teeth and control teeth were recorded at the same time. Thirty-seven posterior partial fixed implant prostheses in 33 patients were followed for 3-12 months. The relative occlusal forces of the implant prostheses were substantially lower at baseline than those of the corresponding control teeth.After 3 months, the relative occlusal forces of implant prostheses had significantly increased, while control teeth decreased significantly, resulting in no statistical significance between them. The implant prostheses occlusion time ratio also increased significantly from 2 weeks to 3 months. There was also no significant difference from the third month to the sixth month, or from the sixth month to the twelfth month.[46]

Thanathornwong et al conducted a study for the prediction of occlusal force from the size and color of articulating paper markings in bruxism patients. This study established a correlation between the occlusal force on the occlusal splint expressed by the size (pixels) and color (RGB) of the articulating paper marks. The weak correlation found between the occlusal force and the pixels shows that the bite force is poorly predicted solely by the size of the articulating paper marks. The result is in agreement with Qadeer et al, which indicates that the size of the articulating paper marks is an unreliable indicator of the applied occlusal force. However, a strong correlation was found between the bite force and the size of the eccentric on the articulating paper and the color using the multiple linear regression equation. The multiple regression model was incorporated into the decision support system. By evaluating the accuracy of the system using patient data, T-scan was shown to be highly accurate in predicting the occlusal force on the occlusal splint of bruxism patients.[47, 48]

Dimova-Gabrovska stated that clinical protocol for articulation of complete dentures under digital control in combination with articulation paper allows the proper selection of contacts in articulation of dentures in the maximum intercuspation by overcoming the subjective factor.[49]

Forrester et al conducted a study to determine the effect of four indicators Parkell, silk, T-Scan sensor and paper on surface electromyography (SEMG) activity during occlusion. Surface electromyography recordings of anterior temporalis and superficial masseter activity and the subjects' perception of each indicator were measured. SEMG activity with the T-Scan sensor and paper was significantly different (higher masseter activity) compared to that for natural dentition. The Parkell and silk gave no significant differences to natural dentition. Similarly, subjects perceived that T-Scan sensor and paper had the greatest effect on occlusion and were the least comfortable. Thus, the very plastic T-Scan sensor and very thick articulating paper both affected SEMG activity during occlusion.[50]

Conclusion

The prosthetic construction involves the important component of occlusal development. The occlusal component has to be checked, verified at every stage of prosthetic construction for achieving occlusal stability. Multiple occlusal analyzers are available, but among them use of shimstock, foils, silks, mylar strips, articulating paper (8- 100 micron thickness) are common. Use of T Scan gives more occlusal dynamic details which any conventional methods may not provide. The mixed use of technology and conventional technique can be beneficial in analyzing both static and dynamic occlusal contacts.

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