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EVOLUTION OF OCCLUSAL ANALYSIS METHODS: FROM ARTICULATING PAPERS TO T-SCAN

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ABSTRACT

It is important not only to examine the occlusion, but to be able to record, store, and transfer the information in prosthetic dentistry.The articulation of the teeth/prosthesis with respect to simultaneous contacts, biting time and biting force should be assessed by the clinicians as required by the disciplines.However, measuring dental occlusal forces has been an inexact science, often requiring complex and subjective decisions.Dysfunctions like temporo-mandibular pain can be caused even if smallest high spots measuring just a few microns are present .In the fitting of prosthetic devices, occlusal indicators are widely used to obtain information on tooth contacts during occlusion.A wide range of indicators exist ranging from articulating papers through to the T-Scan pressure measurement system.These devices differ not only in their measurement characteristics but also in their material properties such as thickness and plasticity.The aim of this article is to provide an insight to various occlusal indicators available, their advantages and disadvantages in the clinical world of prosthodontics and T-SCAN in particular.

INTRODUCTION

Occlusal contacts are defined and located with the help of occlusal indicators.Traditional concepts of traumatic occlusal interferences involve a single anterior or posterior tooth, which is in "supracontact" during maximum intercuspation or on excursive jaw movement which are collectively called occlusal interferences.The patient will probably not bite on the new prosthesis but rather move his lower jaw into a physiologically unsound position to avoid any unpleasant sensation.The new bite of convenience causes irregular muscle activity which can eventually lead to temporomandibular joint pain and myalgia.Achieving occlusal markings on moist occlusal surfaces over some restorations such as gold, metal alloys and ceramics has been a real challenge.It is important to understand the patterns of tooth contact, properties of materials and methods used to record these tooth contacts for an accurate examination of occlusion in prosthodontic treatment.[1]

Occlusion indicating materials and techniques used in the past and present

There are various materials that have been used in the past and present to detect the occlusal contact points.[1]

1) Articulating paper
2) Foils
3) Occlusal sprays
4) Silicone impression material
5) Polyether rubber impression bites
6) Transparent acetate sheets
7) Mylar paper strip/Shim stock films
8) Pressure indicating paste
9) Modelling wax
10) Silk strips
11) Typewriter ribbon
12) Occlusal sonography
13) Photo occlusion
14) Pressure sensitive films
15) T – Scan

Discussion

ARTICULATING PAPER:

To detect high spots, articulating papers are commonly used.The width, thickness and dye type of the articulating paper enables it to leave a mark of either a point or a surface.The color coating of many articulating papers consists of pigments, waxes, and oils, a hydrophobic mixture which repels saliva (hydrophilic) consisting mainly of water.2 High spots can be detected easily as dark marks and contacts as light marks.They are supplied in the form of strips and horse shoe shaped sheets (Bausch articulating paper Inc, Nashua, NH, USA).Only dark colored spots should be ground when grinding selectively.The major disadvantages of articulating papers have been that they can be easily ruined by saliva, are thick, and they have a relatively inflexible base material; all of these factors result in a greater number of pseudo contact markings [2,3][Fig-1a]

Fig 1a

Fig 1b

Fig 1c

Fig 1d

FOILS:

Foils are the thinnest indicator materials which give more accurate readings than paper and silk.On glossy surfaces and under reduced pressure, their marking capacity is less evident which means that greater pressure must be applied for the clinical use of foils[4][Fig-1b]

OCCLUSAL SPRAYS:

Occlusal sprays are universal color indicator to test occlusal contacts and are easy to administer (Arti-Spray) and leaves a thin colored film which can easily be removed with water, leaving no trace of residues.They are applied at a distance of 3-5 cm onto the

occlusal surface.When testing occlusion all contact points will be immediately visible.These are available in colors: green, red, blue and white[1]. [Fig-1c]

SILICONE IMPRESSION MATERIAL:

In an occlusal study, Ziebert and Donegan used silicone putty to check occlusal contacts after occlusion adjustments in their patients.Silicone putty interocclusal records were made in the intercuspal and in the retruded contact position immediately after each set of impressions were made.The location of tooth contacts was observed as perforations in the silicone putty records.Liqua-Mark, a color indicator, was painted into the perforations of each record with a fine camelhair brush to produce discrete markings on the casts.Different colors of the color indicator were used to differentiate between the intercuspal and retruded contact positions.Millstein[1] used photographic method to compare occlusal contact marks made on acrylic resin casts with perforations that occurred in a silicone interocclusal record.The author concluded that the occlusal contact markings might be specific for, and a product of, the occlusal indicator papers and might not represent the contact surfaces determined by the silicone interocclusal records[1][Fig-1d]

TRANSPARENT ACETATE SHEETS:

Davies et al. described a clinical method termed the occlusal sketch technique as a means of recording occlusal contacts.The sketch consists of an acetate sheet on which a schematic representation of the teeth is drawn, including the occlusal surfaces of the posterior teeth, the palatal surfaces of the maxillary anterior teeth and the labial surfaces of the mandibular anterior teeth.The same authors concluded that this technique demonstrated interoperator and intraoperator reliability in recording occlusal contacts in vitro.The aim of the occlusal sketch technique is to provide a simple and reliable means of recording and transferring information about the location of marked occlusal contacts.It may also be used by the technicians to verify occlusal contacts when articulating casts and fabricating indirect restorations[1]

MYLAR PAPER / SHIMSTOCK FILMS:

The shim stock 8 mm in width and was positioned over the tooth evaluated. When the participants close in Intercuspal Position, teeth holding the shimstock were con- sidered to have occlusal contact with their antagonists. In this manner, proceeding tooth by tooth around the dental arch, the dentist identifies the teeth with contact. Metallic shimstock films is composed of metallic polyester-film of 12microns thick. A combination of color coating and metallic film offers extra advantage of high spot precision over conventional shimstock films[Fig-2a].Anderson et al. reported on the reliability of dentists' ability to evaluate occlusal contacts in the intercuspal position.They compared an articulating paper method against a Mylar paper method and found the latter to be more reliable. In a study of the thickness, strength and plastic deformation of occlusal registration strips used to detect occlusal contacts patterns,Halpern et al. found that some recording methods(those with a stiff marking media)induced artifacts in the contact detection process.These investigations are good beginning if a better understanding of the weakness and strength of the entire clinical occlusal examination are over to be achieved[3].

Fig 2a

Fig 2b

Fig 2c

Fig 2d

MODELLING WAX:

Ehrlich and Taicher recorded occlusal contacts by placing the wax on the occlusal surfaces of the maxillary posterior teeth and having the patient close into maximum intercuspation.The wax occlusal records were subsequently examined in front of a light screen.After recording the quality of occlusal contacts, each registration was placed on the diagnostic cast to visualize and verify the exact location of each contact (supracontact, contact, and near contact).This methodology was not tested for either interoperator or intraoperator reliability.Murray suggested that the clinical recording and transfer of information using waxes have disadvantages relating to inaccuracy and problems of manipulation[1][Fig-2b]

OCCLUSAL SONOGRAPHY:

The first studies to detect tooth contact by the sounds generated during mouth closure began to appear in the literature in the 1960s one commercial device was produced in the mid 1980s called "Dental Sound Checker".The device, based on the principles put forth by Watt, was developed to evaluate occlusal contact sound patterns during closure in an attempt to detect occlusal disturbances.Klifune et al measured the duration of the occlusal sound in a single subject before and after occlusal adjustment and reported a clear decrease in the duration of the occlusal sound with adjustment[1]. [Fig-2c]

PHOTO-OCCLUSION:

In a photo occlusion system, a thin photoplastic film layer is placed on the occlusal surface of the teeth; the patient then is asked to occlude on the film layer for 10 to 20 seconds.The film layer is removed from the mouth and inspected under a polariscope light.This technique is reported to be "difficult to apply". Gazit et al. compared the results of occlusal examination of 11 dental students by means of photoelastic wafer and articulating paper.The results were transferred to a graphic occlusal scheme. Neither technique was found to be highly reproducible [1]. [Fig-2c]

PRESSURE SENSITIVE FILMS:

A newer but essentially similar device has been introduced (Dental Prescale, Fuji Film, Tokyo, Japan).This device also records the location and force of contacts with the force sensitive film.Hattori et al. evaluated the reliability of this device for occlusal force measurement both on a subject and on casts.They reported the linear relationship between the applied and measured loads. Araki et al. used this device in 5 patients with TMD and evaluated the distribution and area of the tooth contacts and the total occlusal force.The primary limitation of the contact sensor and the pressure sensitive film device is that the recording medium is far too thick and results in heavier contacts on the posterior teeth than the anterior teeth.Further, this sensor thickness disturbs the persons finding attempts to close into the intercuspal position.This is because a study on interocclusal thickness discrimination has shown that aluminium foil as thin a 20 micrometer can give bite-disturbing proprioceptive information to a subject[1]

T-SCAN:

The development of a prototype computerized occlusal analysis (T-Scan; Tekscan Inc, South Boston, Mass) was reported by Mannes et al. The T-Scan instrument was designed to examine and record occlusal contacts by computer analysis of information from a pressure- sensitive film. The T-Scan system is stated by the manufacturer to digitally record both the location and timing of tooth contacts. The tooth contact information is presented by demonstrating moments of time in the sagittal axis and transverse axis of the occlusal plane. Time moments are defined as the sum of distances of the tooth contacts in millimeters from the x or z axis of the occlusal plane multiplied by their relative time value (1-sec) and divided by the sum of the onset times. The manufacturer purports that, when the time moments in these axes are analyzed, an occlusion can be uniquely described .

In this system, electrical resistance develops with the applied force. When the patient occludes on the sensor, the particles come together in the force applied areas, di- minishing the electrical resistance. The u-shaped sensor foil is 60microns thick, consists of

an X-Y coordinate system with 1500 sensitive receptor points made of con- ductive ink, and is subject to elastic deformation. When an operator properly uses this technology, mark size, mark color-depth, donut-shaped halo contacts, as well as other color and mark appearance characteristics, are ignored as force indicators and used only as contact locators .

The first occlusal contact that results when the mandible is closed on a correct centric relation axis is known as the centric relation prematurity. This procedure (T-Scan) combines bimanual manipulation with the simultaneous recording of the sequence of resultant tooth contacts using a computerized occlusal analysis system. Several researchers have reported that the sensors do not have the same accuracy among themselves and have fewer contacts than conventional methods, such as articulating papers However, it has been shown that the pressure- sensitive film method is not as accurate as the silk ribbon and detecting occlusal contacts. For this reason, it appears that the clinical applicability of the T-Scan system is limited. The sensitivity of the T- scan sensors has been reported to decrease or disappear when the sensors are used more than once.

Mizui et al. measured the timing and force of occlusal contacts in both 60 normal subjects and 5 patients with an unspecified craniomandibular disorders (CMD) using the T-Scan system. They reported that in the nor- mal subjects the timing and force of occlusal contacts were symmetrical and the center of effort was located in the first molar region. For patients with CMD, the timing and force of occlusal contacts were asymmetric and the center of effort was not always located in the first molar region, as determined with the T-scan system[1]. [Fig-2d]

CONCLUSION

When used more than once, the articulating papers, foils, silk strips, and T-Scan system tested as occlusal indicators were associated with different rates of decrease in contact numbers. The success of the T-Scan system was negatively affected by repeated use of the sensors. Occlusal records obtained in wet and dry environments were significantly different. Occlusal contact numbers increased greatly when the teeth were dry; drying the mouth thoroughly before testing therefore may affect the success of occlusal analysis. Every material has its own limitations in someway, be it age-old materials like wax or impression materials or the latest technology of T-Scan. The choice to use any one out of the above mentioned materials depends upon the clinical situation, clinician's choice and expertise, economics and comfort.[1]

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