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Marking the invisible – A review of the various occlusal indicators and techniques.

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Abstract
Occlusal harmony is an important entity for the success of either removable or fixed restorations in the discipline of prosthetic dentistry. Occlusal contacts should not only be able to be examined but to be able to record, store and transfer the information as well. The ultimate goal of any restorative treatment is to establish dental occlusion that is in harmony with the stomatognathic system.
Occlusal indicator or occlusal testing material is a medium which is used to locate and define occlusal contacts in prosthetic restorations. Various occlusion testing materials have been used over the years to indicate any occlusal interferences. A thorough knowledge of the various occlusal indicators available, prior to their usage is necessary to understand the correct method of use, interpretation of their markings and their limitations. The purpose of this review article is to overview the various materials and methods that have been used as occlusal indicators[1].

Keywords: Occlusal indicator, occlusal markers, occlusal contacts, occlusal supracontacts, occlusal interference

Introduction
Knowledge about occlusion and occlusal contacts is indispensable for dental practitioners to have a successful dental practice. These occlusal contacts are subject to constant change with most of the tooth restorative procedures like simple Glass Ionomer Cement or composite restorations, removable or fixed prosthesis, orthodontic treatments and dental extractions. Occlusal interference is any tooth contact that inhibits the remaining occluding surfaces from achieving stable and harmonious contacts (according to GPT9).
Occlusal interferences involve single or multiple anterior or posterior tooth or teeth which is in 'supracontact' during maximum intercuspation or excursive jaw movement. An occlusal interference of even few microns can trigger severe irritation, which can lead to tooth pain, tooth mobility, wear facets, widening of periodontal ligament space, temporomandibular joint pain and myalgia [1].
The true occlusal contact time simultaneity by definition implies that a time of 0 second elapses between the first and the last contact. This implies that, all the occluding surfaces should meet at the same instance during mandibular closure and the aim of Occlusal therapy is to achieve this relationship. Near contacts are those areas that range from a contact to a gap of 0.5 mm between the occluding surfaces while non-contacts are those areas wherein there is a 0.5-2 mm separation of the teeth[2]. The patient's perception of occlusal thickness ranges from 12.5 to 100 µm.
Occlusal indicators/ occlusal markers/ occlusal testing materials are used to locate and define occlusal contacts in any restoration. Occlusal indicators are used in prosthetic dentistry to determine occlusal contact locations and for recording and transferring patient's inter-occlusal relationship onto an articulator for the fabrication of dental prosthesis.
The thickness of occlusal indictors should be less than the patient's perception. When an occlusal indicator of thickness which is more than the patient's perception is used it can indicate tooth contact between teeth where no contact exists and introduce proprioceptive impulse which causes the jaw to be deflected. For proper well-being of the patients' stomatognathic system and for a successful occlusal therapy it is important to understand the patterns of tooth contact, properties of materials and methods to record these contacts [2].

Classification of occlusal indicators

Occlusal indicators are broadly classified as qualitative and quantitative indicators.

They can also be classified as digital and non-digital / conventional / traditional.

Qualitative/non-digital/conventional indicators include articulating paper, film, silk, high spot indicator, wax, foil, metallic shimstock etc.

Quantitative/digital indicators include T-Scan, photo occlusion, virtual dental patient.

Qualitative indicators determine the location and number of tooth contacts whereas quantitative indicators determine the time, sequence and force characteristics of tooth contacts [3].

Materials used as occlusal indicators

Qualitative / non-digital indicators

Wax Articulation Paper: Articulating papers are the most frequently used qualitative indicators to locate occlusal contacts intraorally as well as extraorally (in dental laboratory). The colour coating of many articulating papers consists of waxes, oils, pigments and a hydrophobic mixture. Few manufacturers produce them with special bonding agent called transculase (Bausch articulating paper Inc, Nashua, NH, USA), or wetting agents like lecithin an additional emulsifier which gives them bonding properties on moist occlusal surfaces.

Articulating paper comes in strips and in horse shoe shape. They are manufactured in different thickness, which may range from 25 - 350 µ. Thicker papers have the tendency to mark not only contacts but also produce pseudo-contacts. Articulation paper is available in a variety of colours (blue, red, green, orange and black) [4].

The characteristic marking is observed as a central area that is devoid of the colorant and surrounded by a peripheral rim of the dye. This region is called "target" or "iris", owing to their appearance and it denotes the exact contact point. These target points are identified and adjusted to achieve harmonious occlusion.

The major disadvantages of articulating papers is that they can be easily ruined by saliva, are thick and have a relatively inflexible base material; all of these factors result in a greater number of pseudo contact markings.

Bite intensity detecting articulating paper: This was invented and patented by August Kokal in 1976. It comprises of an upper paper and lower paper or mesh layer and many ink granules which are interposed between the two. Each of the ink granule is encased by a membrane which, for each colour have different thickness so as to be rupturable at different biting pressures. For example green ink granules have thin membrane which is designed to be rupturable at biting pressure of 300-500 psi, red ink granules at 500-700 psi, blue have thicker membrane to rupture at biting pressure of 700-1000 psi.

This articulating paper would mark the teeth with different colours which gives the operator a clear picture of the different points of occlusion with the different biting pressures.

Articulating silk strips: Articulating Silk Strips are made from high quality natural silk, consists of fibrils which are tube shaped protein structures and has extremely high colour reservoir capacity (Bausch articulating silk, 80 microns, Bausch articulating paper Inc, Nashua, NH, USA). This silk is highly tear-resistant and because of its low thickness and good flexibility it adapts perfectly to cusps and fossae. Because of their texture, they do not produce pseudo contact markings [1].

Silk strips are usually saturated with ink and hence they may be used several times on the same patient before they need to be replaced [4]. The disadvantage with silk strips is that, they loose their marking ability when the stain components are dried.

Articulating foils: Articulating Foils are known to produce more accurate readings than paper and silk owing to their thickness which is around only 8 µ. The limitation of foils is that their marking ability is less evident under reduced pressure and glossy surfaces. Hence greater pressure must be applied for the clinical use of foils [1].

The Artifol articulating film (Bausch Inc.) has thickness of just 8 µ, which is less than the thickness perception level of the patient. It must be used with special holders in a dry environment. It is universally applicable, both intraorally and on lab models [2].

They are also manufactured with an additional emulsifier which gives them bonding properties on moist occlusal surfaces. This is achieved by adding special bonding agent-transculase, or wetting agents like lecithin [1]. On occlusal contact, the colouring agent is expelled from the film and the bonding agent binds it on to the tooth surface

Mylar Paper / Shimstock films: Mylar Paper / Shimstock films are available in different thickness with polyester base ranging from 12 – 22 µ. They are also available with ink coatings on both sides or a combination of colour coating on one side and metallic coating on the other side [2]. The film is positioned over the teeth to be evaluated and the patient is asked to close in maximum intercuspal position, the tooth/ teeth holding the shimstock is considered to have occlusal contact with their antagonists [4].

Fleximeter strips: Fleximeter strips help to measure the height of the preparation. They are made of silicone rubber which can be sterilized to the temperature of 200°C. They are available in 3 different thickness: 1mm, 1.5 mm and 2 mm. Occlusal indicator paint can be applied onto these strips and can be used as a marking indicator while measuring the height of the preparation.

Gnatho-film: Gnatho-film is a soft and flexible occlusal film developed by Bausch. It is Ultra thin 16 µ polyethylene, with a colour coating of 6 µ consisting of waxes with hydrophilic components. This unique film adapts perfectly to the individual conditions of the receptive occlusal surface and is extremely tear resistant. The flexibility of polyethylene as well as soft colour coating enables precise checking of the actual contact points. It is available in various colours like green, red, blue, black and in different sizes (20x60 mm or 70x100mm).

Dental floss with a pressure sensitive material

Interproximal contacts are as important to the dentist as occlusal or biting contacts, during seating of crowns and bridges. Articulating floss impregnated with a pressure sensitive material may be used to mark tooth contacts interproximally between one tooth and an adjacent tooth.

The cells containing the pressure sensitive material ruptures in response to interproximal pressure caused by the distance between one tooth and an adjacent tooth being smaller than

the diameter of the dental floss.

Silicon putty material: Silicone putty can be mixed and placed on the occlusal surface and interocclusal records are made. They are then trimmed and placed on the casts. The location of tooth supracontacts can be identified as perforations in the silicone putty records. The interocclusal record is then placed on the occlusal surface of the teeth or cast and a colour indicator is painted into the perforations of each record with a fine camel hair brush. This would produce markings which can be adjusted to eliminate them.

Alginate impression material index: Spatulated alginate impression material is applied on the occlusal surfaces of posterior teeth and the patient is asked to bite on it with light to moderate pressure till it sets. After their careful removal, the left and right indexes are examined against light and the number and location of perforations are then transferred onto the patient's cast or intraorally with indelible pencil. The supracontacts are identified and reduced in the patients mouth [1].

Scannable bite registration material: This material has a reflective surface. It delivers excellent results when capturing images with intra oral scanning devices. This allows dental professionals to incorporate antagonist data directly in the design of tooth restorations with CAD/CAM technology (eg: virtual CAD bite registration material).

Wax: Occlusal waxes are thin sheets of wax (28g-32g) which are placed on the occlusal surfaces of teeth and the patient is asked to close in maximum intercuspation. The wax can be examined intraorally or extraorally in front of a light screen for perforations. The wax does not leave any direct marks on the tooth structure and adjustment must be made by relating the perforations on the wax to visualize and locate on diagnostic casts [3]. It is easy to use and clinically flexible. The limitations of occlusal wax are related to inaccuracy, unstability and difficulty in manipulation[1].

High Spot Indicator: It is a liquid contact colour (Arti-spot, Bausch articulating paper Inc, Nashua, NH, USA) which is applied to the occlusal surface with a brush. These indicators are made by dissolving food grade pigments which is completely safe in a volatile solvent. On application of the material onto the test surface, the solvent evaporates in seconds leaving a thin film of pigment behind. The thickness of the layer of indicator is around just 3 µ thick.
Every contact with this layer would destroy the colour at that exact point of contact. The base material then shines through and high spots can easily be detected. It can also be used to test for high spots on highly polished occlusal surfaces such as gold or ceramic. The layer can easily be removed after use with hot water or alcohol [1]. It is also used for testing the accurate fit of crowns, inlays, onlays, telescopic crowns and clasps [3].

Occlusal Sprays: These occlusal indicators are available in spray form which is used to test the occlusal contacts and accurate fit of crowns and bridges [3]. They are sprayed onto the test surface from a distance of around 3-5 cm. They are easy to administer and leaves a thin coloured film which can easily be removed with water, leaving no trace of residues. Upon occlusion the material will be removed at the contact points which makes it easy to identify. These are available in various colours like red, blue, green and white [1].

Occlusion sonography: They evaluate occlusal sound patterns during closure to detect occlusal disturbances. Kifune *et al*. evaluated the occlusal sound in a single individual before and after occlusal adjustment and reported decrease in the duration of occlusal sound after adjustment. The way in which the individual closes the teeth can influence the nature of occlusal sound produced. The patients should be well trained to close with constant force and speed. They can be used to evaluate the occlusal fit of a newly fabricated single crown or on loading of implant abutment [2].

Quantitative / digital indicators

Photo-Occlusion: In this system a thin photoplastic film layer/ memory wafer is placed on the occlusal surface and the patient is asked to occlude on the wafer for 10 to 20 seconds. After which it is removed from the mouth and inspected under a polariscope light [1].
The location and intensity of occlusal contacts are verified and the results are then transferred to a graphic occlusal scheme [5].
Light contact is seen as yellow, orange or red colour and shows 40% of light penetration. In medium contact the colour patterns are blue centered within the light coloured pattern and the percentage of penetration is 40-48%. In heavy contact the color pattern is yellow and orange within the blue center and the percentage of penetration is 48 to 60% [3].

Virtual Dental Patient: This uses the modern virtual technology which is a recently introduced concept. Scanners are used to acquire three dimensional data from the patient or dental cast. This provides quantitative information that would aid in the assessment of his chewing function and in identifying the occlusal interferences. Valid occlusal contacts can be calculated from aligned virtual casts. The preferred method of calculating contacts uses virtual casts aligned with virtual interocclusal records [3].

T-Scan: T-scan is an occlusal indicator or device which has brought unprecedented accuracy in the analysis of dental occlusion. It helps us to measure dental occlusal forces and quantify how well balanced a patient's occlusion is. The system components include a sensor and support, a handle assembly, the system unit, computer software and a printer [2].
When patients bite on the sensor, the resultant change in electric resistance is converted into images on the computer screen. There are two modes in which the program can be operated: time analysis and force analysis. Time analysis provides information on the location and timing of contacts displaying on the screen with the first, second and third or more contacts in different colours. Force analysis shows the location of contacts and their relative forces in five different shades of colours.
T scan system is a great tool to ensure occlusal loading of dental implants, before, during or orthodontic treatment and for locating painful teeth. It also provides a very easy graphic way to interact with patients on the presence of their issues by providing excellent documentation and communication hence increasing patient involvement and treatment acceptance.

Other materials of historical importance

Impression plaster: Impression plaster is basically plaster of Paris with modifiers. Modifiers accelerate setting time and decreases setting expansion. Records of impression plaster are accurate, rigid after setting and do not distort with extended storage. It is difficult to handle because the material is fluid and unmanageable before setting. The final interocclusal record is brittle. The supracontacts perforate through the plaster and hence they can be identified, marked and adjusted intraorally.

Carborundum Stripping technique (1970): The material used in this technique is Waterproof carborundum (silicon carbide) abrasive paper. The material is placed between the occluding surfaces and the patient is asked to do excursive movements. The advantages of this method is that it is less time consuming, economic and readily available. The disadvantage is that when the teeth are in end-to-end as in working occlusion, reductions of both the buccal and lingual cusps will result [3].

Silicon carbide grinding paste: The paste is applied directly on the occlusal surface of the teeth and the patient is asked to do functional grinding movements. It has the right combination of abrasive material to smooth out trouble spots. 20 µm silicon carbide is ideal for minimal interference correction.

Typewriter Ribbon: Ziebert and Donegan used typewriter ribbon to mark occlusal interferences in their patients for occlusal adjustments. Interferences were marked and contacts were verified with 0.00l inch shim stock [1].

Transparent acetate sheet: 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 an outline representation of the occlusal surfaces of the posterior teeth, the palatal surfaces of the maxillary anterior teeth and the labial surfaces of the mandibular anterior teeth are drawn. The use of acetate in this manner facilitated viewing of the marked occlusal contacts from both sides [3].

Conclusion

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 of the above mentioned materials depends upon the clinical situation, availability, clinician’s choice, expertise, economics and comfort.

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