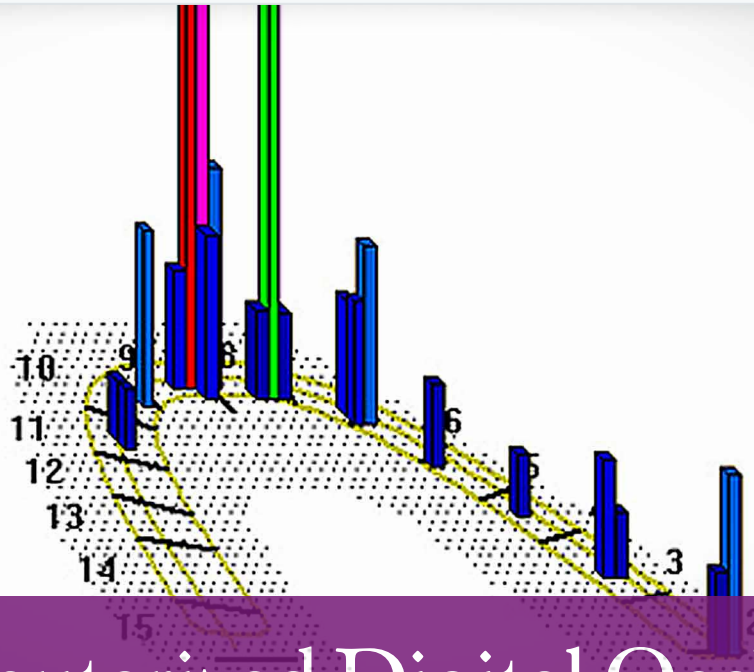

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Computerized Digital Occlusal Analysis of Occlusal Splints

A Peer-Reviewed Publication
Written by Dr. Roger Solow

Abstract

One benefit of occlusal splint therapy is a reduction in masticatory muscle hyperactivity related to the development of an optimal programmed occlusion. This normalization of muscle activity can reduce the effects of cumulative adverse force on the teeth, periodontium, muscles, and temporomandibular joints. Current literature defines a therapeutic occlusion as multiple, bilateral posterior teeth contact with the mandibular condyles physiologically seated and immediate separation of the posterior teeth by the anterior teeth in all excursive movements. These contacts are usually identified by occlusal marking but research has shown that conventional identification of occlusal contacts with inked silk, paper, or plastic ribbon is not accurate. The rationale and application of computerized digital occlusal analysis to verify a therapeutic occlusion with occlusal splint therapy is presented. The advantages for clinical documentation and validation of research are discussed.

Educational Objectives:

At the end of this self-instructional education activity the participant will be able to

1. Implement the basic and clinical science of occlusion in splint therapy.
2. Utilize the specific requirements for a therapeutic occlusion with splint therapy.
3. Further explore the use of a high technology improvement in splint therapy using computerized digital occlusal analysis.

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Author Disclosure

Dr. Roger Solow discloses that he is a lead visiting faculty and Pankey Scholar at the Pankey Institute.

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One benefit of occlusal splint therapy is a reduction in masticatory muscle hyperactivity related to the development of an optimal programmed occlusion. This normalization of muscle activity can reduce the effects of cumulative adverse force on the teeth, periodontium, muscles, and temporomandibular joints. Current literature defines a therapeutic occlusion as multiple, bilateral posterior teeth contact with the mandibular condyles physiologically seated and immediate separation of the posterior teeth by the anterior teeth in all excursive movements. These contacts are usually identified by occlusal marking but research has shown that conventional identification of occlusal contacts with inked silk, paper, or plastic ribbon is not accurate. The rationale and application of computerized digital occlusal analysis to verify a therapeutic occlusion with occlusal splint therapy is presented. The advantages for clinical documentation and validation of research are discussed.

Introduction

Adverse occlusal forces that occur when teeth contact improperly can affect all parts of the stomatognathic system: the teeth, periodontium, masticatory muscles and temporomandibular joints (TMJs). A comprehensive dental examination should evaluate all factors that could cause pain or deterioration in these structures. Assessing the occlusion is an integral part of this procedure. Both clinical examination and mounted diagnostic casts can be used to educate the patient on the effects of their occlusal relationship on the teeth and associated structures. Thorough diagnosis and discussion of a problem list and treatment options must precede any treatment. For some patients, definitive therapy with equilibration, restorative dentistry, orthodontics, or jaw surgery is appropriate to resolve the occlusal problem. For other patients, the optimal treatment may be a noninvasive and more conservative approach with an occlusal splint (OS) used prior to or instead of definitive procedures.

There are many advantages to using OS therapy before definitive procedures. The patient can preview a corrected occlusion and better understand the cause and effect of a structural disorder. The dental professional can assess the effect of occlusal correction on the patient's problem set. The patient can be stabilized with reduced pain to allow for phased treatment in the future. Condylar position can be verified by tracking the consistency of occlusal markings. The time spent with OS therapy at delivery and post- operative refinement helps to develop the dental professional-patient relationship. The dental professional learns the physical and emotional effects of treating that patient and the patient can appreciate the care from the first step of a well thought out treatment plan before committing to irreversible procedures.

Dental professionals often fabricate an OS for patients who present with significant attrition of the teeth or myogenous pain in the masticatory elevator muscles.[1,2] Covering the occlusal surfaces of the teeth with an OS protects those teeth during unconscious nocturnal bruxism. Research has shown that providing a therapeutic OS occlusion decreases the hyperactivity and associated pain of masticatory muscles.[3-7] Okeson described the mechanism of muscular hypercontraction and the resultant pain.[8] There is a circuit of events from teeth to nerves to muscles to teeth. Prolonged posterior teeth contact time leads to prolonged compression time of the periodontal ligaments. Afferent neural impulses from periodontal ligament mechanoreceptors reach the trigeminal motor nucleus and are relayed to the trigeminal spinal tract nucleus which connects to efferent nerves to the masticatory muscles. These constant impulses result in persistant masticatory muscle contraction and further posterior teeth contact. Prolonged muscle contraction creates lactic acid buildup and toxic ischemia in the muscle fiber, resulting in pain.

Optimal occlusion for occlusal splints

The same occlusal scheme on the OS is used to treat both attrition and muscle hyperactivity by providing an optimal force distribution to the uncovered arch.

There are 3 requirements for an OS therapeutic occlusion:

1. Multiple, bilateral, and even posterior teeth contact on mandibular closure.
2. Mandibular closure occurs with the condyles physiologically seated in the glenoid fossae.
3. Anterior teeth immediately separate posterior teeth in all mandibular excursions.[9,10]

Bilateral, even contacts on posterior teeth decrease the force on each individual tooth. An arc of closure interference on a single posterior tooth concentrates all the force of closure on a single tooth. This adverse force stimulates a neurophysiological protective response via the mechanoreceptors of the periodontal ligament to program muscles to avoid the traumatic tooth contact.[11-14]

When the mandibular condyles are seated in the glenoid fossae there is mechanical stability that permits precise rotation of the mandible into repeatable anterior and posterior tooth contacts on the OS. High levels of force can be comfortably distributed to the TMJ in this position when there is a normal condyle-disc-fossa relationship. If the condyles are not seated in the fossae, they are in a protruded position against the slope of the articular eminence. This is an unstable position requiring constant bracing, or hyperactivity, from the inferior lateral pterygoid muscle and does not allow the same level of chewing force.[15]

The inclination of anterior teeth is designed for excursive contact. They are farther from the TMJ with less force on them than posterior teeth due to Class III lever system of the jaw. Anterior teeth contact with posterior teeth disclusion decreases elevator muscle activity, is comfortable, and prevents posterior teeth wear.[16-18]

In order to fulfill the requirements for proper OS occlusion a full arch design with a hard surface is needed. Segmental or soft OS use is not recommended. A segmental OS causes extrusion of the uncovered teeth and intrusion of the covered teeth.[19] The result is a deformity with the anterior and posterior teeth occupying separate horizontal planes. Orthodontics may be needed to correct the discrepancy between these occlusal planes. Unless this type of orthodontic movement is needed to correct an existing occlusal plane problem, a full arch design is required since it maintains the occlusal plane.

A soft OS permits all teeth to contact during closure and excursions since the material is compressed, precluding an accurate occlusal scheme. A soft OS is difficult to keep clean,and can wear down rapidly as the canines impress into the material and permit posterior teeth contact with high forces during excursions. It is not unusual to see a soft OS worn through, whereas this will not occur on a properly fabricated hard OS with anterior guidance and only vertical force on posterior teeth. A soft OS is not as retentive as a properly fitting hard OS that snaps to place by using the slight undercuts of palatal or lingual tooth contours. The lack of retention creates movement that also prevents the development of precise, repeatable occlusal contacts. The effect of a hard and soft OS on the electromyographic (EMG) activity of masticatory elevator muscles have been evaluated by Okeson and Al Quran and Lyons. They found that the hard OS decreased elevator muscle activity while the soft OS increased activity, contrary to the goal of pain reduction through muscle relaxation.[20,21]

Anterior teeth contacts against the OS in lateral, protrusive, and lateral protrusive excursions should be customized for each patient so that the teeth with the best periodontal support provides the guidance. These contacts mark as continuous lines while the posterior teeth contacts show as small dots. A line adjacent to a posterior tooth dot indicates an excursive interference that laterally torques the opposing tooth. The large roots and greater peridontal ligament surface area of the central incisors and canines make them the logical candidates to take the force during mandibular excursions. Lateral incisors have the smallest roots and should only have light contact in mandibular closure and no contact during excursions. Alternatively, the canine and then the central incisor can sequentially contact the OS to share force between these two teeth during a single lateral or protrusive excursion. Distributing force over two teeth minimizes the force on each tooth and allows a smaller OS as each contact track is shorter.

Dental professionals typically use the same marking media to adjust the occlusion on an OS as for restorative procedures. However, inked silk, paper, or plastic have been shown to be inaccurate in identifying occlusal interferences. There is no correlation with the size or intensity of the mark and the size or intensity of the actual occlusal contact.[22-25] The ink mark indicates that there was a contact but a heavy contact shows a light mark, a medium contact with a medium to thick mark, and no contact appears as no mark. The lighter the contact the thicker the ink mark.[26] Ink marks are also affected by a wet or dry surface and the number of uses.[27] The lack of accuracy of marking media limits the quality of the therapeutic occlusion achieved with the OS.

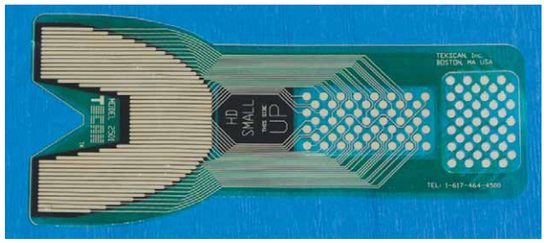
Technological advances in occlusal analysis

Dental professionals can improve the quality of OS therapy by refining the occlusal marking with advanced technology that analyzes the forces that generate these marks. Computerized digital occlusal analysis (CDOA) (Tscan 3®, Tekscan, Boston, MA) is a high technology modality that quickly generates a force movie of the occlusal contacts. The Tscan 3® is the only CDOA equipment currently available. The location, timing, and relative force of each contact is displayed in a 2D and 3D view. A center of force analysis shows the net balance of right and left side forces: the "eveness of the bite" that the dental professional strives to attain. Registration of occlusal forces can be taken when the patient closes in maximum intercuspation (MI), is guided into centric relation (CR) with bimanual guidance, or performs any mandibular excursion.

Maness published the use of CDOA to quantify occlusal contact information in 1987.[28] It has gone through an evolution of development and is currently a handle with an autoclavable sensor support and a disposable, U-shaped, plastic 85u thick sensor that registers occlusal contact at 5-10u (Figs 1,2). The handle connects to the computer via a USB port. The system stores all data of each closure and excursion to document the occlusal contact of the natural dentition, tooth or implant supported restorations, partial and complete dentures, and OS adjustment.

Figure 1. CDOA handle containing the electronics for interpreting occlusal data that connects via a USB port to the computer.

Figure 2. 85u thick plastic disposable sensor. The lines contain ink that changes resistance with pressure, generating force data.



The sensor contains lines of pressure sensitive resistive ink oriented in rows and columns. The intersection of these lines forms a sensel. Pressure on the sensel decreases the electrical resistance.[32] The electronics of the instrument scan the sensels at a 495 cycles/second to determine the change in electrical resistance and thus the force.

Kerstein has published extensively from 1990 to 2012 on the use of the CDOA to guide occlusal adjustment to treat myofascial pain dysfunction (MPD).[29-39] He measured real time EMG data showing normalization of masseter and temporalis muscle hyperactivity with the computer guided correction of occlusal interferences. Resolution of chronic pain was long lasting once the source of the pain, adverse force on posterior teeth, was treated. This was done without the use of drugs, physical therapy, or counseling. Success was predicated on a defined occlusal scheme with bilateral even posterior contact in MI and immediate lateral excursion canine guidance that discluded the posterior teeth within 0.4 seconds.

Wang and Yin used CDOA to correlate premature contacts, long disclusion time, and occlusal force asymmetry with temporomandibular disorders.[40]

The same technology can be applied to OS therapy. First, the OS is adjusted to be stable on placement with no rocking and comfortable to teeth, lips, and tongue. The OS must have zero mobility in both vertical and horizontal dimensions. Any movement precludes attaining a precise and repeatable occlusal contact scheme that is required for a predictable therapeutic result. Relining the OS with the same acrylic resin that it was fabricated from will result in a stable and retentive fit. This can be accomplished with a thin mix of acrylic resin placed inside the OS and seated intraorally. The OS is rotated up and down on one side while the acrylic is setting to mold the internal contour of the OS. This creates a contour that will have the OS rotate into place and seat with a snap or click, but that is resistant to vertical dislodgement. Alternatively, the OS can be relined on an accurate stone cast if the volatility of the acrylic resin is not tolerated by the patient.

The occlusion is adjusted with marking ribbon to create the occlusal scheme fulfilling the above requirements (Fig 3). This author uses 20u ribbon for occlusal marking. Most adjustment is done with the patient in a supine position since patients typically use the OS when sleeping and the condyles seat easier into their physiological position.[41] The occlusion should be checked in both supine and upright positions so that any change in jaw posture does not create an uncomfortable contact.

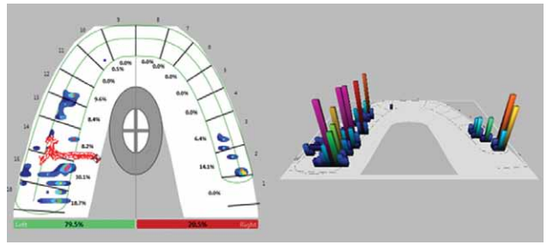
The occlusion should be checked both during patient self closure and CR closure with bimanual guidance for optimal occlusal contacts. The patient should confirm that the bite is "even on both sides" and that "no front teeth hit harder than back teeth".

Figure 3. Mandibular occlusal splint with 20u ribbon marking. Point contacts on posterior teeth indicate only vertical force on the opposing teeth. Continuous lines on anterior teeth indicate the anterior guidance contacts.

The lateral excursions should have all contact on the canines with no posterior teeth contacts lateral to their point contacts. A lateral excursion contact on a posterior tooth will detract from the smooth guidance desired on the canine as the canine tooth can be slightly lifted off the OS.The canine contact should be a smooth, continous line and the patient should be able to slide from medial to lateral and lateral to medial on this line without any discernible "hitches" or "jerky movement". The lateral movement is then repeated with operator assisted force at the angle of the mandible on the non-working side directed medially and superiorly to detect non-working contacts that may occur with mandibular bending during heavy bruxing.[42] An inclination of the canine guidance acrylic ramp will facilitate immediate anterior guidance with posterior teeth disclusion.[43]

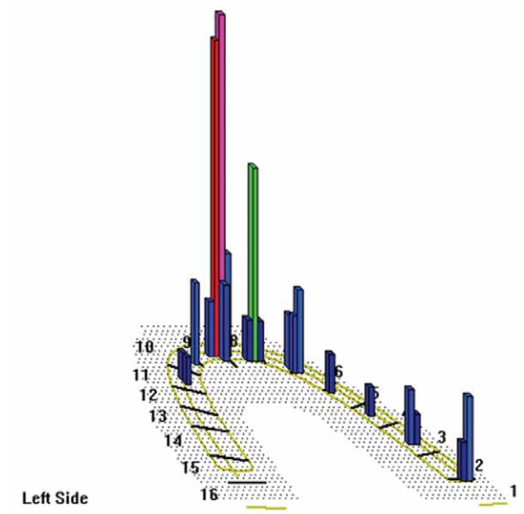
After all occlusal marking are perfected, CDOA is then used to analyze the occlusion. The appropriate size sensor and holder are attached to the handle which is connected to the computer. The patient information is entered into the computer file including data such as central incisor width, missing teeth, and spaces to customize the arch form. A multi-bite scan label is chosen and the sensor is centered against the labial aspect of the OS. The patient clenches on their back teeth for several seconds, repeating this 3 times to condition the sensor. This clenching allows for slight sensor crimping and deformation in and around the tooth anatomy, as the sensor is fabricated flat.[32] Natural teeth typically have cusp incline to cusp incline contacts before occlusal adjustment, so the crimping of the sensor should create a closer adaptation of the sensor to the tooth. However, OS contact is a flat surface against the opposing cusp tip, so the need for conditioning of the sensor is minimal. The sensitivity is adjusted by the operator and computer prompt so that 256 levels of force can be recorded (Fig 4).

Figure 4. Mandibular closure force movie frame of the occlusion in Figure 3. The apparently even occlusion with ink marking actually shows unbalanced contact force. Note the number and intensity of predominant left side contacts.



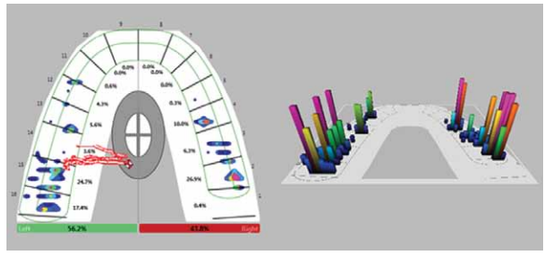
It is important to tell the patient to gently "close on their back teeth" to make sure they are in the right position and not closing on the sensor support. When using the sensor on natural teeth, the interdigitation of cusps and fossae helps to orient mandibular closure into a repeatable pattern. Closing on a flat OS with a smooth plastic sensor over it does not provide this orientation and it is possible to inadvertently close on the anterior teeth (Fig 5). If the dental professional observes only anterior teeth contact on the scan, the patient is asked to practice closing on posterior teeth so that their contact is visible on the scan.

Figure 5. Mandibular closure force movie frame, different case than Figure 4. The patient was asked to close on the back teeth, but actually protruded with contact on teeth #7,8.



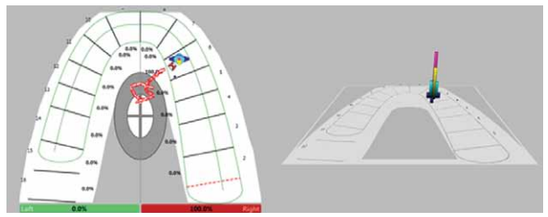
The patient repeats a series of clenches on their back teeth for several seconds and the occlusion is analyzed for force distribution. The OS is adjusted so that sites with excess force are reduced with an acrylic bur or rubber wheel and the process is repeated until there are no anterior teeth contacting with greater force than posterior teeth. Both left and right sides should contact evenly so that the center of force icon is in the oval target (Fig 6).

Figure 6. Mandibular closure force movie frame after occlusal refinement guided by CDOA. Note the balanced number and intensity of contact. The center of force icon (red/white square) is in the oval target. The retained left 3rd molar adds more contact area to the left side, shifting the icon left.



A right lateral excursion scan is chosen on the computer and self guided right lateral excursions are performed with the patient instructed to clench and then slide to the right (Fig 7). After immediate disclusion of posterior teeth within 0.4 seconds is confirmed again, the lateral movement is repeated with operator assisted force at the angle of the mandible on the non-working side directed medially and superiorly to detect non-working contacts that may occur on heavy bruxing. The same protocol is repeated for left lateral excursion.

Figure 7. Right lateral excursion showing posterior teeth disclusion and contact forces solely on the canine. Increasing the incline of the canine contact path facilitates immediate posterior teeth disclusion.



Protrusive excursions are then checked, especially on a patient with a pronounced curve of Spee or retained third molars. Posterior teeth are discluded during protrusion by both condyles traversing down the articular eminence, minimizing the chance of protrusive interferences. Posterior teeth must be carefully examined for lateral excursion interferences since only the orbiting condyle traverses down the articular eminence helping to disclude posterior teeth, the rotating condyle does not provide disclusion. This may ex-

plain why working-side interferences contribute the most to masticatory muscle hyperactivity.[29] For this reason, canine guidance is preferable to group function for OS design.

Discussion

Kerstein's research documented the effect of precise and complete occlusal correction on masticatory elevator muscle activity and the clinical resolution of MPD. One premise of OS therapy is that a therapeutic occlusion will have a beneficial effect on that patient. However, it is unrealistic to assume that because an OS was delivered it has an excellent or acceptable occlusion. This is important to understand and convey to patients who may decline the recommendation for a proper OS based on their negative experience with a previous OS. In this author's practice it is very unusual to have a patient bring in an OS that fulfills the requirements for proper fabrication and occlusion. Marking and photographing the patient's existing OS should be part of the complete examination. Comparing their OS with an example of a proper OS can help the patient understand the specific deficiencies that resulted in a lack of comfort or a poor clinical result.

The requirements of proper OS fabrication with optimal occlusion also applies to clinical research. Dental professionals rely on research to be objective and directly applicable to clinical decision making. Research that aims to identify the role of occlusal correction in OS therapy should logically test a perfected therapeutic occlusion against a deficient occlusion. It is common for studies to identify the type or general design of OS, but not provide verification of the actual occlusion tested with photographs or CDOA scans. CDOA relative force graphs readily provides this documentation and confirm that the test variable is a therapeutic occlusion. This technology provides a new standard of verification for the validation of dental research.

CDOA evaluation of natural dentition occlusion has been shown to be consistent and accurate *in vitro* and *in vivo*.[32,44-46] Helms et al. measured the *in vitro* force and direction before and after marking ribbons and CDOA sensor insertion. They concluded that any marking product creates an altered occlusion, similar to the Heisenberg Uncertainty Principle, and that any indicator medium displays an artifact of the contact and not the actual contact.[47] Forrester et al. found altered EMG activity of the masseter muscle before and after clenching on a 202u thick paper ribbon or a 96u CDOA sensor, where 24u marking film showed no change.[48] They concluded than an occlusal change from a thick marking medium occurred since a change in EMG may indicate a change in the occlusion. However, it is important to understand that the CDOA sensor is not used as an occlusal marker. Instead, it interprets the significance of very thin ribbon markings and combines the advantages of these marking ribbons with digital timing and force data. OS contact with the opposing posterior teeth is always a cusp tip to flat surface that minimizes any concern that indicator thickness or rigidity would cause a deflective contact on closure that could alter jaw position.

If an OS is delivered with inappropriate occlusal interferences, then the dental professional has not corrected the occlusion, but has simply altered the sites of the malocclusion. The lack of verification that a completed adjustment of the OS was done to achieve a therapeutic occlusion may explain why some investigators see little difference in the results of using soft, hard, or non-occlusal splints and conclude that OS treament results are largely due to the placebo effect.[49-51] The literature has shown that non-occlusal splints do not provide the same level of myogenous pain relief as OSs.[52-54] Dorland's medical dictionary defines placebo as an inactive substance.[55] An OS is not a placebo by definition since it alters all the occlusal contacts of the highly sensitive dentition and periodontium and infringes on the tongue space which has been shown to suppress masseter muscle EMG activity.[56]

Dental professionals may assess the occlusal contacts by placing 8u shimstock between the teeth as the patient closes. Similar to clinical observation of the occlusion or the use of conventional ribbon marking, the result of this test is affected by intrusion of natural teeth. If an adjacent tooth has a premature contact there may be no actual contact on the tested tooth. Intrusion of that adjacent tooth on closing may allow contact of the shimstock on the tested tooth which would be interpreted as a desired contact, that is in fact absent.

After adjustment of the OS so that even bilateral posterior teeth markings are achieved, the dental professional may palpate the masseter and temporalis muscles as the patient lightly closes on their posterior teeth. The goal is to discern if one side of the patient's elevator muscles fires before the other, indicating an earlier contact on that side of the OS. An EMG recording of masseter and temporalis muscle activity on mandibular closure may be a more objective way to do this.

It is common to ask a patient after any procedure involving the bite to comment on how everything feels. Although this may show that the dental professional cares about the patient's comfort, subjective evaluation by the patient is not consistent or accurate. This is especially true for procedures that patients have not experienced, such as extensive restoration or occlusal equilibration. It is not unusual for them to comment on premature contacts and then mention "I'm not sure" or "I can't really tell". The patient may fear their comments may be incorrect or mislead the dental professional. Highly anxious or critical patients can be stressful to work with when they are given control of determining which areas should be adjusted or when the procedure is completed. Patients cannot be expected to correctly make occlusal refinement decisions, this remains the dental professional's responsibility.

A significant advantage of CDOA is that it gives an objective recording of the timing and relative forces on teeth and restorations. Small or faint ink marks may be significant intereferences but not interpreted as such by the dental professional unfamiliar with current research. These show as clear problems on the 2D and 3D scan graphs. CDOA data shows the patient that the goal of an optimal occlusion has been achieved and that this is the correct stopping point. CDOA changes the explanation of a procedure from something that is abstract to a visually understandable concept. Patients can readily compare the pre-operative and post-operative scans. It is best to ask for patient feedback after all the details are refined and show as even timing and intensity of contacts on the scan.

For many dental professionals, taking a hands-on course with an OS fabricated for their own mouth is the experience that gives them the understanding of the importance of occlusion for their patients. Additional study and practice is required to master this technology. A participation/hands on course will provide in depth knowledge of the details that create clinical excellence. The diagnostic and technical skills learned with OS therapy translate into excellence with occlusal equilibration and comprehensive restoration.

Conclusion

OS therapy is an important treatment modality since there are many patients with attrition and myogenous orofacial pain that can benefit from protection and pain relief. Verifying a therapeutic occlusion is prerequisite to determining the effect of occlusal correction on that patient. Dental professionals need to be aware of the requirements for OS design and fabrication that lead to predictable treatment results. CDOA dramatically improves the dental professional's ability to diagnosis, create, and document an optimal occlusion, a critical aspect of OS therapy. Objective data of occlusal contact forces in 3D format show the patient and dental professional where the problem is and the results of treatment. The specification of the actual occlusion tested is essential for the validity of dental research.

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Questions

1. Occlusal splints are commonly used to help patients with attrition of teeth and myogenous pain in the mastictory muscles. How are splints constructed differently to solve these problems?
a. Splints used to treat dental attrition need to be at least 3mm thick.
b. Splints used to treat dental attrition should have all posterior teeth contact in all mandibular excursions to protect the smaller, inclined anterior teeth from trauma.
c. Splints used to treat myogenous pain should have anterior and posterior touch in all mandibular excursions to share the force over the maximum number of teeth.
d. Splints used to treat dental attrition and myogenous pain are constructed identically.

2. Which one is *not* a requirement of occlusal splint therapeutic occlusion?
a. Multiple, even, bilateral posterior teeth contacts on mandibular closure.
b. Both condyles are physiologically seated in the glenoid fossae on mandibular closure.
c. The patient should be able to open past 40mm.
d. Anterior teeth immediately separate posterior in all mandibular excursions.

3. Anterior teeth are the best choice to guide the mandible in excursions because:
a. They form a pivot or fulcrum in a Class I lever system.
b. They are inclined and decrease elevator muscle activity when back teeth separate.
c. They are the longer teeth with better leverage than posterior teeth.
d. They are the least sensitive teeth and tolerate occlusal load the best.

4. If the condyle is not properly seated in the glenoid fossa, it is braced in a protruded position on the slope of the articular eminence by which muscle?
a. Inferior lateral pterygoid muscle.
b. Anterior temporalis muscle.
c. Masseter muscle.
d. Medial pterygoid muscle.

5. Soft occlusal splints are sometimes used by dentists. Which statement is true?
a. Soft splints are beneficial as compression during mandibular closure allows more teeth to touch and bear the load evenly.
b. Current soft splints are resistant to occlusal wear.
c. Soft splint are easy to keep clean.
d. Soft splints are not recommended as the material precludes an accurate occlusal scheme.

6. Anterior teeth that provide guidance and separate the posterior teeth during mandibular excursions against the occlusal splint should always contact so that:
a. The maximum number of anterior teeth touch.
b. Only the canines touch in excursions of any direction.
c. The teeth with the best periodontal support provide the guidance.
d. Both the central and lateral incisors should touch in all excursions.

7. Dentist use the same marking media to adjust occlusal splints as restorative work. Which statement is true?
a. The thinnest ribbon is always accurate.
b. Thick ribbons affect the occlusion identical to thin ribbons.
c. The size and intensity of an ink mark correlates well to the size and intensity of the actual occlusal contact.
d. Inked silk, paper, and plastic are not accurate in identifying occlusal contacts.

8. There are advantages to using computerized digital occlusal analysis compared to conventional inked ribbons. Which one of these statements is *not* true?
a. Digital occlusal analysis is a new high technology procedure invented in 2008 by Maness.
b. Digital occlusal analysis quickly generates a record for documentation of each scan.
c. Digital occlusal analysis records a force movie and each frame can be analyzed.
d. Unlike marking ribbons, digital occlusal analysis records the time of contact as well as the intensity of contact.

9. The computerized digital occlusal analysis sensor records forces during mandibular closure and excursions. Which of the following is *not* true?
a. The sensor is 85u thick and can register occlusal contact at 5-10u.
b. The sensor records plastic deformation and is analyzed with a laser source.
c. The sensor contains columns and rows of resistive ink and pressure on the sensor decreases electrical resistance that is analyzed as force data.
d. The sensor is disposable.

10. Computerized digital occlusal analysis can be used in a variety of clinical situations. Which one is *not* true?
a. Partial dentures and complete dentures are candidates for use.
b. It is important to control forces on implants by analyzing the occlusion.
c. Natural teeth after orthodontics should have the occlusion assessed.
d. The ankylosis of implants precludes the use of digital occlusal analysis.

11. Kerstein's studies used computerized digital occlusal analysis to guide occlusal correction for myofascial pain patients. Which is a true statement?
a. Drugs, physical therapy, and counseling were essential to treatment success.
b. Success was predicated on immediate lateral excursion canine guidance within 0.4 seconds.
c. He found elevator muscle hyperactivity was not affected by occlusal interferences.
d. He found that relief adverse forces on posterior teeth only gave temporary relief of pain.

12. Computerized digital occlusal analysis can be combined with occlusal splint therapy to verify that a therapeutic occlusion is attained. Which instruction should *not* be given to the patient?
a. Always bite gently on the back teeth to avoid biting the sensor holder.
b. Always bite gently on the back teeth before clenching firmly.
c. Always bite gently on the back teeth before sliding into excursions.
d. Always slide in all directions as if you were bruxing at night.

13. Posterior teeth are separated during mandibular excursions by the anterior teeth and the condyles traversing down the articular eminence. Which statement is true?
a. In protrusion both condyles traverse down the articular eminence helping to separate back teeth.
b. In lateral excursion the rotating condyle traverses down the articular eminence.
c. In left lateral excursion, the orbiting condyle is the left condyle.
d. In left lateral excursion posterior teeth on both sides should touch the splint at the same time as the anterior teeth for the best force distribution.

14. Occlusal splints must be comfortable for the patient to use them consistently over the long term. Which statement is *not* true?
a. Splints should be placed without rocking or irritating the teeth, tongue, and lips.
b. It is important that the patient confirms that the splint closes "evenly on both sides".
c. Only upper splints should be used to avoid infringing on the tongue space.
d. It is important that the patient confirms that "no front teeth hit harder than back teeth".

15. Research has shown that occlusal marking ribbon is *not* accurate. Which statement is *not* true?
a. Computerized digital occlusal analysis analyzes the forces on teeth shown by thin ribbon marking media.
b. Computerized digital occlusal analysis is both a marking medium and analyzes the forces on the teeth.
c. After the occlusal scheme looks correct to ribbon marking, the computerized digital occlusal analysis is used to refine the occlusion.
d. Computerized digital occlusal analysis records contact forces and when they occur as a force movie.

16. Many dentists work with their patients lying down, some have them sit up. Which statement is true?
a. The jaw posture slightly changes when the patient sits up or lays back, so the bite on the splint must be comfortable when the patient closes in either position.
b. Since patients generally wear the splint at night for nocturnal bruxism protection, the splint should be adjusted only with the patient laying down.
c. Since the occlusal splint is generally flat, it doesn't matter whether the patient has the splint adjusted laying down or sitting up.
d. Since the jaw joint is a universal joint that allows freedom in many positions, the splint can be adjusted either laying down or sitting up.

Questions (Continued)

17. What is the center of force analysis?
   a. The center of force shows where the most efficient chewing occurs, typically in the molars.
   b. The center of force shows the net position of the balance of forces and should be in the oval target to attain an even bite.
   c. This is the average or median force exerted during all the closure recordings.
   d. This is the force required to shift the mandible over to a centered position under the maxillary midline.

18. The author recommends a full arch design with a hard surface for a precise occlusal scheme. Which is ***not*** a true statement?
   a. A full arch splint design maintains the occlusal plane.
   b. A segmental splint design that does not cover part of the arch allows intrusion of the covered teeth and extrusion of the uncovered teeth.
   c. Some patients benefit from occlusal plane correction with a segmental design splint.
   d. Segmental splints are smaller and therefore a better design than full arch splints.

19. Prior to using computerized digital occlusal analysis on a patient, how do you customize the arch form so that the data is recorded to match the teeth or implants in the mouth?
   a. Measure from mandibular first molar to first molar at the mesiobuccal cusp.
   b. Estimate the tooth size to be small, medium, or large.
   c. Measure the central incisor width and record any missing teeth and open spaces.
   d. This is not important to do, we are only concerned with left and right forces.

20. A placebo is defined as an inactive substance. An occlusal splint is not a placebo because:
   a. The splint alters all the occlusal contacts, affects the periodontal mechanoreceptors, and infringes on the tongue space which can suppress masseter muscle activity.
   b. It is not a pill or chemical.
   c. It isn't ingested into the body and doesn't enter the bloodstream.
   d. It can be placed or removed by the patient at any time so the patient controls its use.

21. Which is ***not*** an advantage to using an occlusal splint prior to definitive therapy?
   a. The dentist can assess the effect of occlusal correction on the patient's problem set.
   b. The patient can preview the effect of occlusal correction.
   c. Condylar position can be verified by tracking the occlusal markings.
   d. The thickness of the splint will determine the final vertical dimension.

22. Retention is defined as resistance to vertical dislodgement. Which statement is true?
   a. Soft splints are more retentive than hard splints since they extend into undercuts.
   b. Soft splints move slightly vertically allowing more teeth to touch with a more even occlusion.
   c. A soft splint is not as retentive as a hard splint.
   d. A hard splint is retentive since it extends into the undercuts of the buccal contour of the teeth.

23. Soft and hard splints affect the masticatory muscle electromyographic activity. Which statement is true?
   a. Soft splints increase masticatory muscle activity.
   b. Soft splints decrease masticatory muscle activity.
   c. Hard splints increase masticatory muscle activity.
   d. Soft splints achieved the optimal therapeutic masticatory muscle activity.

24. The anterior guidance on occlusal splints is designed to separate posterior teeth during mandibular excursions. Which of these statements is ***not*** true?
   a. Anterior teeth contact should be customized for each patient.
   b. The teeth with the best periodontal support are the canines.
   c. Anterior guidance contacts mark as a continuous line.
   d. Distributing force over several teeth can minimize the force on each tooth.

25. Relining an occlusal splint will result in a stable fit with no mobility. Which statement is true?
   a. Always reline with a soft liner for comfort.
   b. Do not allow any movement on the splint during the reline.
   c. The splint can be relined either intraorally or on an accurate stone cast.
   d. Use the special reline material and not the material used to fabricate the splint.

26. During lateral excursion occlusal adjustment on the splint, an operator assisted force is used to help detect non-working interferences. How is this done?
   a. Force is placed on the chin during lateral excursions.
   b. Force is placed on the angle of the mandible of the non-working side.
   c. Force is placed on the mandible at the occlusal plane on the non-working side.
   d. Force is placed on the mandible at the occlusal plane on the working side.

27. Evaluation of the patient's splint is part of the comprehensive examination. Which of these statements is ***not*** true?
   a. You should mark and photograph the existing splint.
   b. You can compare the existing splint with an example of a perfected splint.
   c. You cannot assume that a splint will have a predictable result without a therapeutic occlusion.
   d. If the patient could not tolerate a splint it is unrealistic to recommend another one.

28. It is critical to deliver a splint with an optimum occlusion that is comfortable for the patient. Which of these statements is true?
   a. Patients can sense about 15u of occlusal change so they should judge the bite.
   b. Patient evaluation of the occlusion is subjective and not accurate.
   c. Splint adjustment is best controlled by the patient.
   d. Soft splints are more comfortable to the bite than hard splints.

29. Dentists rely on clinical research to be objective and relevant to daily practice. Which of these statemtents is ***not*** true?
   a. Research on occlusal correction should test a perfected therapeutic occlusion against a deficient occlusion.
   b. Most studies verify the therapeutic occlusion used in the study.
   c. Computerized digital occlusal analysis can provide documentation of the actual occlusion tested.
   d. The same requirements of splint fabrication for clinical use apply to dental research.

30. Occlusal splint therapy is important treatment since there are many patients with can benefit from protection and pain relief. Which of the following is ***not*** true?
   a. Verifying a therapeutic occlusion must be done to assess the effect of occlusal correction on that patient.
   b. Computerized digital occlusal analysis dramatically improves the dentist's ability to diagnose and treat with an optimal occlusion.
   c. Computerized digital occlusal analysis is an experimental research tool that is not typically used for patient care.
   d. Objective data shows the patient and dentist where the problem is and the result of treatment.

ANSWER SHEET

Computerized Digital Occlusal Analysis of Occlusal Splints

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5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
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7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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