The Truth About Occlusion

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A commentary on the controversies regarding

dentistry's most important subject.

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Although occlusion principles permeate almost all of dentistry, the area is confounded by confusing theories, non-practical techniques, contradictory 'beliefs,' and practitioners unaware of the basic concepts of occlusion. As a result, most dental patients go without the benefits of dental therapy based on several occlusal principles.

Dr. McCoy's paper presents some well proven, practical concepts in occlusion based on his long experience and sound engineering principles. It is thought provoking and useful.

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Introduction

Everyone agrees that a good understanding of occlusion is essential to ensure optimum dental health. Unfortunately, that seems to be the only point of consensus for this ambiguous subject. One cannot read a text or take a course on occlusion and walk away with an understanding of how the design of teeth and the way they touch each other affect the efficiency and function of the stomatognathic system. Consequently, there are many unanswered questions: primarily, the role that occlusion plays in the etiology of temporomandibular disorders (TMDs) and oral facial pain. The confusion is evident when we hear phrases such as “no one occlusal scheme will serve all patients” and questions like “which concept on occlusion is correct?” We are led to believe that, as general practitioners (GPs), we do not have the expertise to manage problems associated with this subject and are solicited to take specialized postgraduate courses at the Las Vegas Institute (LVI) or the Pankey Institute. However, each of these courses is costly in both tuition (at least $15,000) and time away from the office (2–3 weeks), plus there is the cost of expensive instrumentation.

Patients of dentists who follow such a stylized form of occlusal rehabilitation now have to share in the expense of the learning program, which limits treatment to the affluent. What about the patients who cannot afford it? Most people have little or no dental restorative work done each year. Whether the reason is financial, lack of accessibility, fear, or indifference, that’s the way it is. Those who do frequent their dentists on a regular basis usually restrict their work to limitations set by their insurance. Subsequent work has to wait until next year.

Considering the circumstances, how can the GP take care of occlusal-related problems in a cost-effective way that will benefit patients with limited resources? In order to answer this question, we truly need to understand occlusion, and that is the problem. As it is being taught today, occlusion is incoherent. Taylor explains that, “due to the empirical nature of the literature, the study of occlusion has been extremely complex and troublesome to both pre- and post-doctoral students."[1] Simon likens searching for the truth in occlusion to Alice looking for the right path in Wonderland[2] There are so many diverse opinions regarding this subject that it is not uncommon to witness discord among colleagues at professional meetings. So, what is the truth?

What Is Occlusion?—Definitions as a Major Source of Confusion

It is appropriate to begin with the definition of occlusion because that is a major source of confusion.

The original definition of *occlusion* was the act or process of occluding, from the Latin *occludere*, "to shut up or close up." Dental occlusion refers to the closure of teeth—nothing more.

Today, however, the word has at least three different meanings. *Taber's Cyclopedic Medical Dictionary* limits the definition to: "relation of the teeth when the jaws are closed."[3] *Dorland's Pocket Medical Dictionary* first defined dental occlusion as "the closure of teeth,"[4] then expanded the definition to "the contact of the teeth of both jaws during those excursive movements of the mandible essential to the function of mastication."[5] *Jablonski's Illustrated Dictionary of Dentistry* defines *occlusion* as:

> The relationship between all the components of the masticatory system in normal function, dysfunction, and parafunction, including the morphological and functional features of contacting surfaces of opposing teeth and restorations, occlusal trauma and dysfunction, neuromuscular physiology, the temporomandibular joint and muscle function, swallowing and mastication, psychophysiological status, and the diagnosis, prevention, and treatment of functional disorders of the masticatory system.[6]

The different interpretations are a major distraction to understanding this subject. It clouds the issues and makes questions such as "What has occlusion got to do with TMD?"

impossible to answer. Are we asking if tooth contact during closure is causing a problem with the TMJ, or do we want to know if the stomatognathic system is not functioning correctly? Modern-day texts on occlusion are not on the simple touching of upper and lower teeth, but rather present a detailed analysis of the whole stomatognathic system. Occlusion and the stomatognathic system are two distinct entities and should be described separately to remove the present ambiguity.

The Human Stomatognathic System—How Should It Function Ideally?

There are two principal parts to the stomatognathic system: the maxilla, a U-shaped row of teeth supported by alveolar bone, which is fixed to the skull; and the mandible, which is movable. The mandible houses another U-shaped row of teeth that are embedded in very dense alveolar bone and is attached to the skull by a hinge-gliding joint. Usually, the maxillary teeth overlap the mandibular teeth, but there are many variations due to genetics, such as crossbites and differences in the anterior length of either jaw.

The mandible has three primary functions: communication, mastication, and swallowing. Although the mandible has the capability of three-dimensional movement, the direction of the three primary functions is up and down. The vector of mastication is a vertical teardrop with lateral movement of 5mm to 6mm during the first phase of crushing; as the teeth approach each other, the lateral displacement lessens to 3mm to 4mm from the starting position.[7]

When the mandible is not performing a task and the muscles of mastication are relaxed, the occlusal surfaces of the teeth are slightly apart, creating what is called the "freeway space." The position of the mandible changes anteriorly-posteriorly due to gravitational forces as the position of the head deviates from the vertical. This is easy to demonstrate. If you tilt your head back and swallow, you can feel your posterior teeth lightly touch and then open. If you tilt your head forward and swallow, the contact shifts to the anterior teeth. The different positions of the mandible upon swallowing are insignificant due to the light closure force. What *is* significant is the position of the mandible/condyles during full intercuspation while clenching. Since forces generated by clenching can exceed 300 pounds per square inch, it is important that centric occlusion (CO) coincide with centric relation (CR), because it is in this position that the condyles are positively braced in the anterior-superior portion of their fossæ to receive these strong forces.

The Morphology of Teeth

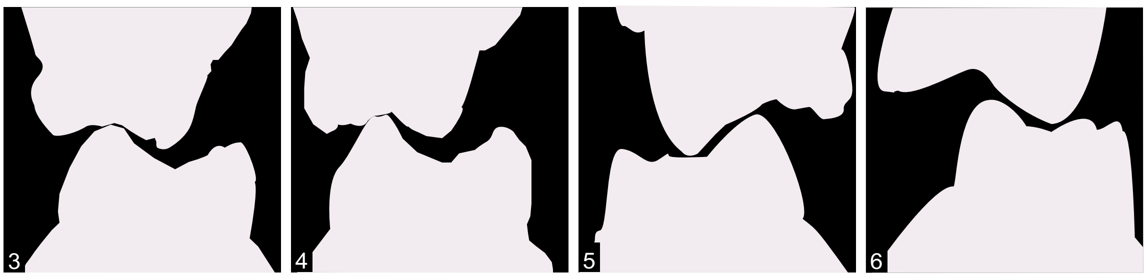
It is the role of teeth to cut food efficiently, aid in speech, bite, and ensure proper condylar positioning upon closure. What is the ideal design for those purposes within the stomatognathic system?

We often hear debates on the question whether form follows function, or vice versa. The question is never satisfactorily answered because it is not a good question. There are, however, design principles that appear to govern the structure-function relationship in organisms—that is, there is an interface between mechanical engineering and biology. The idea is that biological materials and structures have functions for which they are designed.

If we are looking for the ideal design of teeth to ensure healthy occlusion and function, we have to look at nature as the architect of excellence (Figs. 1 and 2).

Figs. 1–2: Nature's Biological Cutting Instruments

Teeth are designed to cut food. If one examines a cross-section of molars and bicuspids in occlusion before they are worn down, there are two noteworthy observations: (a) there is minimal contact between the teeth, which is confined to the tips of the functional cusps; and (b) there is a generous space between the incline planes of the cusps, which is called the intra-incline space (Figs. 3–6).[8]



Figs. 3–6: Sections of Ideal Occlusion

From these observations, it is interesting to note that teeth do not require large areas of contact in order to maintain their position, work efficiently, and be comfortable. But what was nature's intention in providing such clearance between the incline planes? From an engineering point of view, there are four advantages: vertical loading, neutralization, prevention of off-loading, and proper condylar seating.

Vertical Loading

The intra-incline space ensures vertical loading. Misch and Bidez describe normal vertical compression forces as those that are perpendicular to the alveolar bone and maintain the integrity of that bone (Fig. 7).[9]

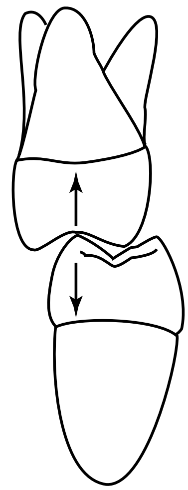


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Fig. 7: Normal Vertical Loading

Neutralization

Neutralization is the desired buccal-lingual position of the tooth by reciprocal action of the muscles of the tongue and cheek. When the incline planes do not touch, the tooth is free to assume a neutral position (Fig. 8).[10]

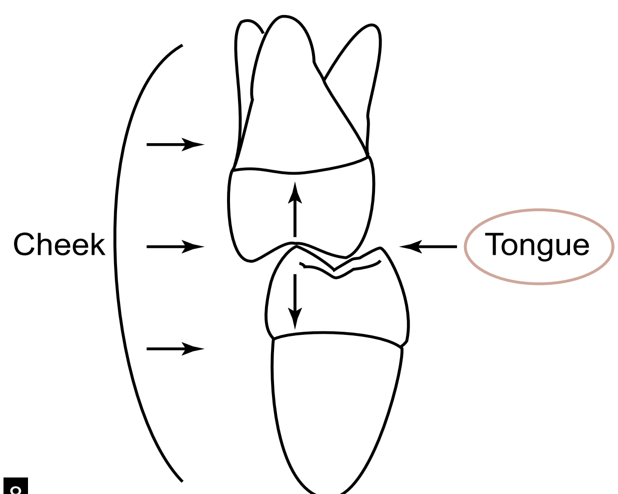

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Fig. 8: Neutralization

Prevention of Off-Loading

When the incline planes of the cusps are in contact, bending or off-loading of the tooth is likely during mastication and compression, resulting in destructive shearing forces, which act parallel to the alveolar bone (see Fig. 9).[11]

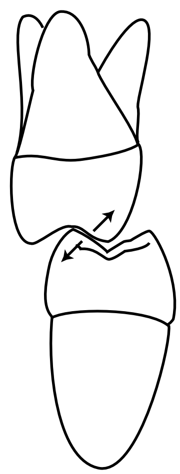

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Fig. 9: Off-Loading

Proper Condylar Seating

The intra-incline space plays a very important role in condylar seating. In 1899, Angle stated: "The occlusion of the teeth is maintained first by the occlusal inclined planes of the cusps."[12] This is a valid statement, but is it what we want? Our objective is for centric relation (CR) to equal centric occlusion (CO). What if, due to clenching and grinding, the mandible has worked its way forward so that CO is anterior to CR, and that position is locked in by the incline planes? If the incline planes of the cusps do not touch, there would be no occlusal resistance when the contracting swallowing muscles reposition the mandible up and back upon closure. If there is no resistance, there should be no impediment to achieving CR (Fig. 10).

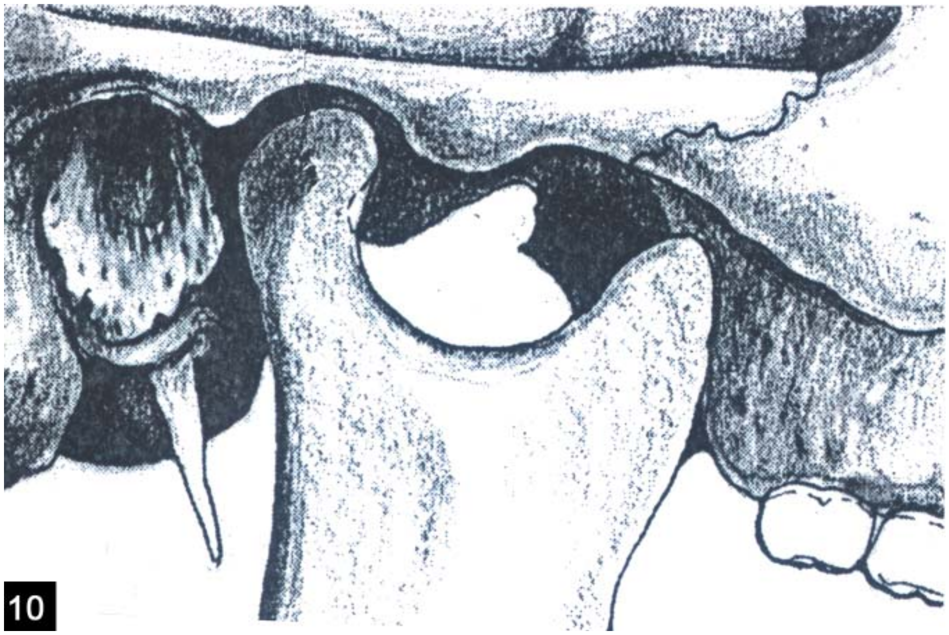

Fig. 10: Correct Positioning of the Condyle

What Happens When the System Dysfunctions?

Regardless of the differences in anatomical configuration between the maxilla, mandible, and number of teeth, the primary reason any stomatognathic system is correct is because it is not affected by any form of abnormal or impaired function. Dysfunction of the stomatognathic system manifests itself by clenching and/or grinding of one's teeth.

Since the late 1800s, this condition has had ten different formal names, such as Bruxism, Neuralgia Traumatica, and Parafunction, to name a few. Some of the names referred to grinding, whereas others implied clenching. The term *Dental Compression Syndrome* (DCS) was coined to encompass all forms of traumatic compression and to achieve better patient understanding.[13]

Why is dysfunction important? Because of the power (300 to 500 pounds per square inch is not uncommon) and the damage that it inflicts upon the stomatognathic system over a lifetime. DCS deserves recognition for its long successful reign from prehistoric to modern times. *Newsweek* reported that DCS is of epidemic proportions and that Americans spend one billion dollars a year for mouth guards to seek relief.[14]

The Etiology of Dysfunction

The flattened dentition of our ancestors tells us that DCS has been epidemic throughout the ages. What causes it? There is no doubt that life stress causes a majority of people to clench and grind their teeth, but there are other factors that have to be considered when consulting with patients:

1. Exercise and Sports: boxing, motorcycle riding, rowing, water skiing, weightlifting, or any sport in which there is a bracing of the body.
2. Psychological Factors: aggression, anger, anxiety, dreaming, fear, pleasure, stress, tension.
3. Medical Factors: oral pain, pain in other parts of the body, sleep apnea.
4. Drugs: amphetamines, caffeine, cocaine, ecstasy, fluvoxamine, fluoxetine, haloperidol, paroxetine, sertraline, and venlafaxine.
5. Bio-Engineering Factors: horizontal distraction of the mandible upon closure, misalignment of the TMJ components, off-loading of teeth, and prematurities.

The Signs of Dysfunction

One reason DCS has been so successful over the centuries is that it works well within one's subconscious. Since few patients affected by DCS are aware of it, dentists must recognize the visual signs of compression in order to address the problem. Beside the obvious signs of flattened dentition and hypertrophied muscles of mastication, there are certain deformations caused by compression that many dentists misdiagnose or don't understand. Nevertheless, these deformations affect dentition, bone, and restorative materials.

Deformations of the Dentition. Classified as non-carious lesions (NCLs), these defects typically are site-specific, in that they appear at the tips of functional cusps and the gingival area of teeth where susceptibility to stress is high (Figs. 11 and 12) A finite element analysis of a tooth model confirms that stress is highest in these areas[15] (Fig. 13).

Fig. 11: Compression NCLs—Tips of Functional Cusps

Fig. 12: Compression NCLs—Gingival Area

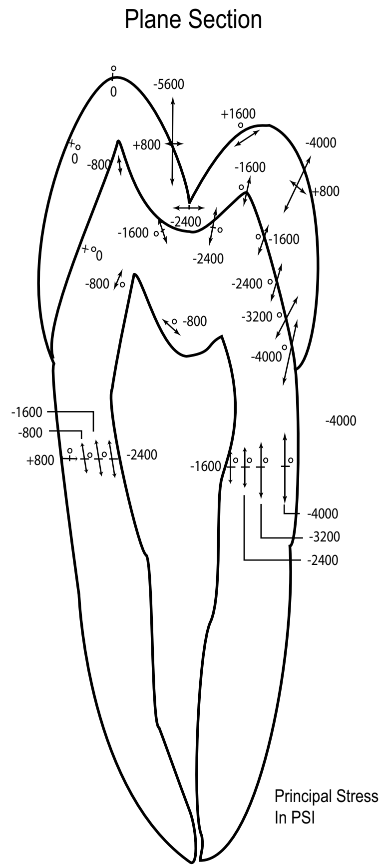

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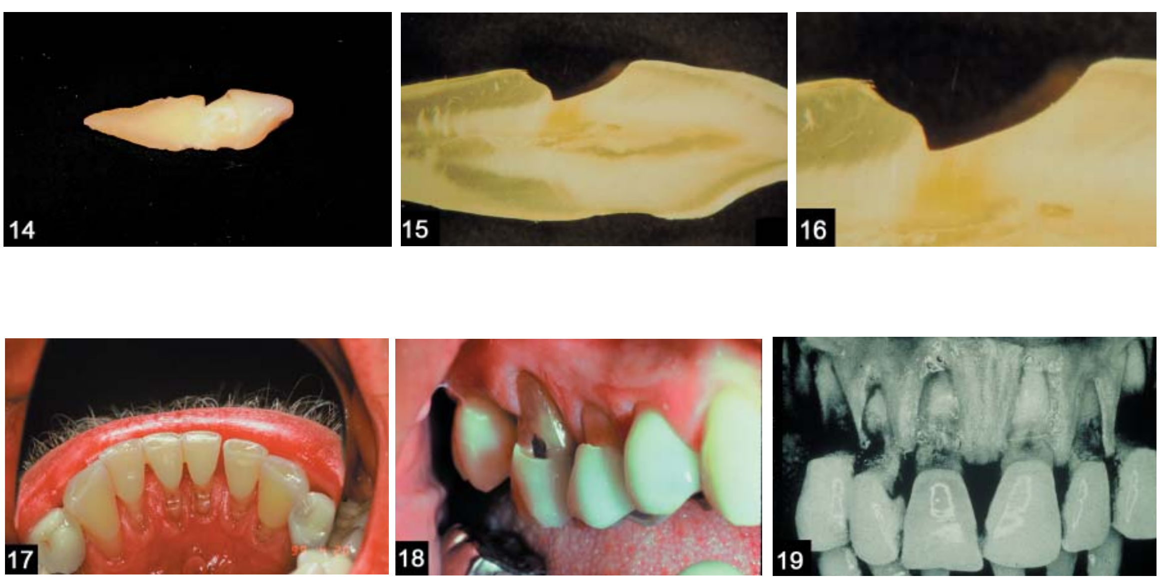
Fig. 13: Finite Element Analysis of Tooth Model

There are two distinct mechanisms responsible for the loss of tooth structure during compression: tensile forces[16] and positive ion egress.[17] Engineers tell us that these high stresses may be responsible for the pain experienced by patients who have restorations in the gingival area, where tensile forces are powerful enough to pull apart the enamel prisms.[18]

Although NCLs can be caused by a variety of agents, such as low pH and mechanical abrasion, compression NCLs are distinguished by a glassy sheen. Kornfeld wrote about this phenomenon in 1932, when he observed that these defects were hard, smooth, and almost glasslike in appearance.[19] This glassy effect may be due to the exit of positive ions from these focal points of high stress.[20] The ions are produced by the compression of collagen in the dentition and alveolar bone — the piezoelectric effect.

It is to be noted that compression NCLs do not appear on all patients who clench their teeth, not only because of variations in the intensity and frequency of DCS, but also genetics. NCLs seem to be more prevalent and dramatic in patients with dense alveolar bone than in patients with periodontally compromised teeth.[21] Compression NCLs have been the subject of controversy among dentists for decades. W. I. Ferrier once wrote that "their etiology seems to be shrouded in mystery."[22] But NCLs are not such a mystery if we understand the science of biomechanics. Subject to distracting labels such as "McCoy's notches"[23] and "abfractions,"[24] these defects require a more scientific identification, which is essential to understanding their significance. What we are actually seeing are multi-shaped examples of hard tissue fatigue (Figs. 14–22).



Figs. 14–19: Various Examples of Compression NCLs[25]

Figs. 20–22: More Examples of Compress NCLs

Fatigue applies to changes in the properties of a material due to repeated applications of stress or strain—in this case, compression failure from DCS. A professor of materials at Reading University, J. E. Gordon, describes fatigue as "one of the most insidious causes of loss of strength in a structure."[26]

If an object, such as a tennis ball, rebounds to its original shape after repeated compression, it is said to be elastic in nature. However, if an object exhibits residual defects after repeated compression, it is said to be plastic in nature. Biological structures, such as teeth and bone, are termed viscoelastic.

Compression fatigue also occurs in the spine (Fig. 23). In orthopedics, these sites of destructive stress are termed compression or wedge fractures.[27]

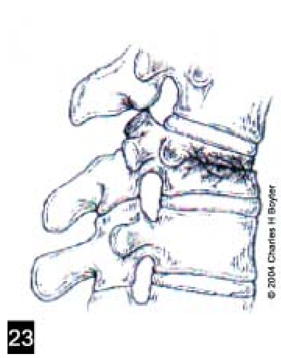


Fig. 23: Vertebral Compression or Wedge Fracture

The compression failure of an object occurs at its most vulnerable site. Teeth are most susceptible at the gingival area (Fig. 24).

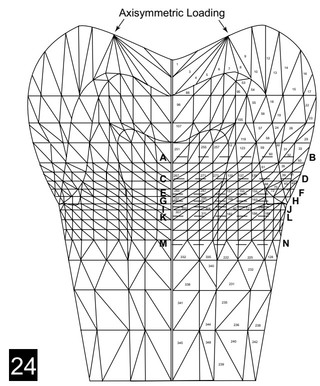
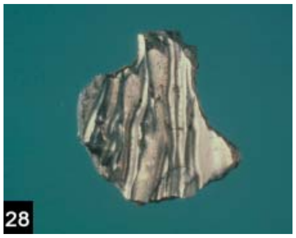


Fig. 24: Axisymmetric Finite Element Model

If alveolar bone recedes, the failure site will also be lowered. Figs. 25 and 26 demonstrate defects that appear in tandem as the supporting bone atrophies, thus changing the fulcrum point. Also note in Fig. 25 that the only occlusal contact is on the incline plane, forcing the bicuspid to be flexed toward the lingual when the patient clenches.

Figs. 25–26: Gingival Fatigue in Tandem

Deformations of Restorative Materials. Fatigue easily manifests itself in prostheses and restorative materials such as amalgam and acrylic. In engineering, these wavy patterns are called "Luder Lines," or molecular slipbands. The explanation for the patterns is that molecules in the alloy are rearranging themselves under the influence of compressive strain. One can demonstrate the effect by bending a metal coat hanger back and forth and examining the stress configuration that is produced. Figs. 27–30 demonstrate Luder Lines in restorative materials.



Figs. 27–28: Luder Lines in Amalgam

Figs. 29–30: Luder Lines in Acrylic
(courtesy of Gregori Kurtzman, D.D.S.)

Deformations of Bone (Exostosis). Articles on torus palatinus and torus mandibularis have appeared since 1814 (Figs. 31–34).[28] Although there is not a consensus on their etiology, many associate their occurrence with TMDs and masticatory hyperfunction.[29] The author has long suggested that the compression of collagen in the dentition and bone generates negative ions that result in exostosis (the piezoelectric effect).[30] A situation such as this may well explain the metallic taste that people experience from time to time.

Figs. 31–34: Examples of Exostosis

Epidemiology

A survey was taken of 100 patients (50 female; 50 male; age range, 17–76) to determine how many exhibited signs and symptoms of DCS and TMD (see Table).[31]

Table: Signs and Symptoms of DCS and TMD

	Overall %	Female %	Male %
Signs of DCS	95	96	94
Awareness of DCS	61	66	56
TMD	34	36	32
Sensitivity to cold	54	62	46
Muscle enlargement	12	10	14
Flattened teeth	58	56	60
Exostosis	54	48	60
Gingival NCLs	58	54	62
Tip of Cusp NCLs	67	68	66

The Management of Dysfunction

The presence of deformations in the oral environment should stimulate a dialogue between the dentist and patient to determine if the patient is currently grinding and/or clenching his or her teeth, or whether this damage occurred during a prior stressful period.

Often a patient will deny any awareness of DCS, but upon returning will say something like, “You know, since you brought it to my attention, I catch myself clenching all the time.” Management of DCS begins with awareness and proceeds with a three-step treatment plan, which consists of education, equilibration, and guard therapy.

Step 1: Education. Dental healthcare providers must teach their patients everything they know about DCS in the simplest terms. Patients need to understand that teeth should only touch upon swallowing, and they should also know the resting position of the mandible (lips together, teeth apart). The list of etiological agents should be reviewed. Patients should be asked to monitor their jaw position during waking hours and be sensitive to headaches and tension in muscles of mastication upon waking. If it is obvious that patients are affected by DCS but are indifferent to the problem, their dental records should indicate that, and no further treatment should be initiated. However, if patients are aware of the problem and want to eliminate or reduce it, the next step is to analyze the occlusion in order to determine if the morphology of certain teeth needs to be modified.

Step 2: Equilibration. An equilibration is a reduction of the working cusp inclines. For easy patient understanding, it is suggested that terms like *equilibration* and *coronoplasty* be avoided, and the procedure be simply described as “a sharpening of the teeth where they meet.”

In order to determine the need for equilibration, the patient’s present occlusion must be compared with a standard of excellence—that is, ideal occlusion. Based upon nature’s original design, ideal occlusion is present when the occlusal contact is confined to the tips of the functional cusps. Dentists are often cautioned against equilibration because it is irreversible. But we have to realize that the tooth or teeth that require reshaping have already been deformed by DCS. The reduction of the heavy contact to the tips of the functional cusps will reduce the forces in the gingival area by minimizing occlusal contact during mastication. If the vertical height of the dentition is not reduced, there is no downside. The procedure will improve the masticatory efficiency and reduce the physical stress on the dentition. After good engineering principles have been applied, it is time to address the stress with a guard and/or counseling.

There are two methods of equilibration: indirect and direct. The indirect method involves repositioning the condyles, mounting the models on a three-dimensional articulator, adjusting the occlusion on the models, and reproducing this adjustment on the actual teeth. The downside of this method is that it is time-consuming, expensive, and not as accurate as the direct method.

The direct method involves utilizing the patient's own stomatognathic system as a biological articulator, employing occlusal indicator wax to demonstrate the contacts in closure, analyzing the areas of displaced wax, and eliminating contacts on the incline planes. The advantages of this method over the indirect one are that it is more accurate, takes less time, is inexpensive, and is easy to perform.

Patients, who should sign a consent form, need to be told that their teeth will not be shortened, and that the benefits (increased comfort and diminished DCS) will far outweigh the conservative loss of enamel. The entire procedure should take no longer than fifteen or twenty minutes. Patients should be seen a week or two after the procedure for final analysis and polishing.

A review of fifteen articles on occlusal equilibrations published in professional journals reveal generalized agreement on the following points:

1. Occlusal adjustment is a misunderstood and under-utilized procedure.
2. Prophylactic adjustments in the absence of pathology are not acceptable.

3. CR should equal CO.
4. There should be no interferences in lateral excursions.
5. The height of the buccal cusps should never be shortened except to eliminate interference in lateral excursions.
6. Traumatic occlusal relationships should be eliminated before restorative procedures.
7. Cusps should touch loosely in the opposing fossæ.
8. Inclined planes should not touch to ensure axial loading.
9. Occlusal indicator wax is the most effective way to demonstrate how teeth touch.
10. There should be no flat plane occlusion in humans.
11. Cuspid-guided occlusion is preferred.[32]

A recent 17-year study evaluated the relationship between gingival fatigue due to DCS and its relief by sharpening the functional cusps.[33] The authors found that the hypersensitivity from gingival fatigue in 246 teeth was relieved by equilibration. The study confirmed that the equilibration specifically involved reduction of the working cusp inclines.

Step 3: Guard Therapy. Although equilibration satisfies the engineering requirements of the problem, and education can help in stress management during waking hours, only a guard can ensure protection during sleep.[34] The question is, what kind of guard—hard or soft and full arch or anterior?

Unfortunately, there are conflicting studies on this issue.[35] Again, we have to evaluate our objectives from an engineering point of view. If our goal is to diminish the force on the TMJ and reduce muscle tension, the best design is a small, thin, hard acrylic appliance that covers the lingual surfaces of the maxillary anterior teeth. It is often referred to as a deprogrammer or mandibular repositioner. A common question regarding this design is, "Do the posterior teeth supererupt?" No, this appliance is not like the Hawley retainer, which is worn virtually all the time. Posterior teeth do not supererupt overnight . If they did, all mouth-breathers would have supererupted teeth.

Regarding hard or soft appliances, a recent study suggests that soft and hard splints are equal in reducing masticatory muscle pain.[36] Although that may be true, there is an additional factor that the study did not include. In my own private practice, I had considerable experience with soft guards and found that they were effective in reducing TMJ stress, but patients often compressed against them simply because they were resilient.

Generally, studies agree that there is an overall reduction of oral-facial pain when DCS is treated with any type of guard,[37] but in my opinion the smaller anterior deprogrammer seems to work best (Figs. 35 and 36).

If the intensity of the DCS is such that the three-step treatment therapy is not effective, biofeedback, hypnotism, physical therapy, and/or drug therapy must be considered.

Figs. 35–36: Anterior Guard

What Is Being Taught Today and Why Is It Incoherent?

The human stomatognathic system is healthiest when it functions vertically, has a naturally sharp dentition, and is free from dysfunction. Is this what is being taught today? Unfortunately, no. There are conflicting ideas about how the mandible moves and how teeth touch each other when functioning normally.

Normal Function: Vertical vs. Horizontal

When one studies the work of the early investigators—Gibbs, Lundeen, Hildebrand, Stallard, Stuart, Rugh, and Smith—it is clear that they all agreed that the mandible functions vertically and that there are only slight lateral or protrusive excursions during mastication. So, then, why are we focused on the way teeth touch each other horizontally, when in fact vertical function is correct? Because dentists are concerned that compressive loads in lateral excursions damage their patients' dentition. Rather than focusing on prevention, dentists developed an interest in the least harmful way that teeth should touch each other during these lateral excursions in order to reduce the destructive shearing forces that act parallel to the alveolar bone. In other words, they were searching for what they call the optimum functional occlusion, which Okeson explained as follows:

> The problem facing dentistry today is apparent when a patient with the signs and symptoms of occlusal pathosis comes to the dental office for treatment. The dentist must determine which occlusal configuration is most likely to eliminate this pathosis. What occlusion is least likely to create any pathologic effects for most people over the longest time? What is the optimum functional occlusion? Although many concepts exist, the study of occlusion is so complex that these questions have not been satisfactorily answered.[38]

This quest for the optimum functional occlusion resulted in a number of very different concepts as to how the teeth should touch each other during lateral excursions, including:

(a) mutually protected occlusion; (b) canine-protected occlusion; (c) group function occlusion; (d) balanced occlusion; (e) theoretically ideal occlusion; (f) physiologic occlusion; (g) non-physiologic occlusion; and (h) anterior guidance occlusion.

Of these eight concepts, the one that is most in vogue at the moment is anterior guidance occlusion. Although this concept is taught in every dental school in the world today, I believe that it is one of the biggest distractions to understanding how the stomatognathic system should normally function. Why? Because it has nothing to do with normal function (mastication) and everything to do with dysfunction (DCS).

The justification for anterior guidance was to reduce parafunctional forces, but as Clark observes:

> The whole concept of canine guidance and canine-protected occlusion is actually a concept that is illogical if protection from parafunction is the subject of debate. That canines do not inherently protect the jaw and teeth from bruxism is clear because in the strong bruxer, the clinical observation of canine attrition is common.[39]

The concept of anterior guidance is also flawed for several other reasons. The most important is that people do not eat in lateral excursions with their teeth closed under heavy compressive forces. This is the horizontal component of DCS. People eat vertically and grind laterally. We are reminded that masticatory forces are approximately 60 pounds per square inch, and that teeth rarely touch during this process, and only lightly when they do.

The credibility of anterior guidance does not hold up under scrutiny. Dawson states that the anterior teeth are the key factor in protecting the posterior teeth.[40] But why do we need to protect the formidable posterior teeth, since they are designed for high-force mastication? Even if we concede that anterior guidance provides a modicum of relief during horizontal DCS, it provides no relief at all from vertical DCS. Consider a patient with a prosthesis supported by endosteal implants in the anterior maxilla, and, while sleeping, that patient thrusts his or her mandible up against the prosthesis. Only a guard, not anterior guidance, will ensure protection for that patient.

One more point. Dawson also teaches that the functional relationship of the anterior teeth is the principal determinant of posterior occlusal form.[41] Others, however, believe that occlusal form is determined not only by anterior teeth but also by the TMJs.[42] But if we are to be accurate and objective, it is genetics that determines the morphology of the dentition. The original design of our body parts is always perfect (with the exception of anomalies) when we first get them. Teeth are beautifully designed to cut food, facilitate digestion, and provide easy accommodation for the mandible during function and closure.

Finally, we have to consider that anterior guidance is not essential to the health and well-being of the stomatognathic system. Patients with class II and III jaw relationships have no anterior guidance, and they function just fine.

McNeill reminds us: “It must be emphasized that the teeth only come together momentarily during swallowing and occasionally during mastication and that at all other times the teeth should be apart in the resting range of the mandible.”[43] If Dr. McNeill’s statement correctly represents reality, why are we obsessed with lateral excursions? Why, when a patient slides into a lateral excursion, do we call it the working side when it is not doing any work at all?

There is no question that the reduction of lateral forces is desirable. There is a question, however, as to the best method to reduce them. Rather than assigning certain teeth to be shock absorbers, it is better to focus on prevention by educating patients and protecting them with comfortable guards.

Morphology and Occlusion of the Dentition

Dentition best serves the stomatognathic system when the original, natural, sharp design is preserved, and the occlusion is confined to the tip of the functional cusps. But that is not what is being taught today. Rather than a loose-fitting occlusion, some dentists prefer a strong bracing occlusion (tripodization), whose purpose is to solidly lock the mandible in place so that the condyle maintains its position. Alternative thinking suggests that we ask why the condyle has migrated and why it cannot return by itself upon swallowing. A plausible explanation is that the condyle has come down and forward due to horizontal DCS and cannot return due to the friction incurred by the incline planes of the teeth. A common symptom of tripodization is clenching, which is a detriment. For dentures, which have only 25% of the masticatory force of natural teeth, it is essential to have a sharp design for optimum efficiency in mastication. Unfortunately, we are offered a choice of four different anatomical configurations for posterior denture teeth:

1. *Anatomic:* with cusp angles of 30 degrees or more
2. *Semi-anatomic:* with cusp angles of 20 degrees or more
3. *Non-anatomic:* with no cusp angles (0 degrees)
4. *Lingual:* with lingual cusp contact only

Since vertical forces used to penetrate a food bolus are minimized with sharp anatomical tooth forms and maximized with flat tooth forms, one has to come to the conclusion that sharp teeth are superior to flat ones for denture wearers. So why are flat denture teeth even considered? Because there is an idea in the profession that anatomical tooth forms, due to their steep cusp angles, create more horizontal or lateral forces than flat tooth forms. This is even more significant in patients with severely resorbed ridges that are less able to resist horizontal forces than patients with fuller ridge contours. Ortman's statement, "The flatter the ridge, the flatter the cusp angles," aptly summarizes this generally accepted concept.[44]

The question is, why is this a generally accepted concept? It doesn't make sense. If we have a patient with a significantly resorbed ridge, common sense dictates that we employ anatomically sharp posterior teeth and instruct the patient to eat vertically, not horizontally. So what is the origin of Ortman's concept? For the most part, it was derived from research that was done fifty years ago.[45] It is important to evaluate that work and to critique the conclusions and recommendations derived from it. The objective of that research was to determine how different occlusal morphologies affected the deformation of dentures during mastication. The concern was that horizontal deformation of dentures could contribute to resorption of the residual ridge.

Duplicate dentures were constructed with three different occlusal configurations: 33-degree, 20-degree, and 0-degree posterior teeth. Two strain gauges, one above the other, were embedded in the lingual flange of the lower denture at the midline, and patients were asked to chew three things: raw carrots, salted peanuts, and artificial boli of latex rubber and cotton rolls. The deformation—that is, the movement toward or away from the midline—was measured across the posterior ends of the denture from the distal end of one lingual flange to the distal end of the other.

The 33-degree posterior teeth caused the greatest horizontal deformation of the denture base during mastication. The 20-degree posterior teeth had 10 percent less deformation, and the 0-degree posterior teeth had 50 percent less deformation.

Deformation of the denture bases during the test procedures had a range of .0000 to .0433 inches (039 inches = 1 mm).

The mean duration of the force during swallowing was 3.6 times greater than during mastication.

There is only one valid conclusion that can be derived from this research: that vertical compression of a denture results in a slight widening (1 mm) of the posterior portion. The researchers theorized that this 1 mm distortion could contribute to lingual atrophy of the alveolar ridge, but that theory has not been validated over the years, since the majority of horizontal atrophy of the alveolar ridge over time occurs on the buccal.

The conclusion derived from this research—that flatter teeth reduce horizontal distortion—is open to interpretation because, the amount of distortion exhibited by lingual flanges against the alveolar ridge is miniscule (1 mm divided bilaterally).

It is interesting to note that the researchers determined that swallowing contributes to a greater transfer of energy to the underlying mucosa than does mastication. This is not only because of the longer duration of the force application, but also because the forces generated by swallowing, unlike those generated by chewing, are purely vertical.

It is common sense that vertical compression of a U-shaped denture would result in a slight widening of the posterior portion due to the higher force application. When flatter teeth were used, the patients' vector of function went from vertical to horizontal, not only diminishing the distortion but also decreasing the efficiency and power of the mastication.

This fifty-year-old research leaves unanswered questions. First of all, why were the stress gauges placed in the midline of the lingual flange and not in the lingual and buccal flanges of the posterior portion of the denture? Second, why were such hard substrates as peanuts and raw carrots used for this experiment? We are told that denture wearers do not yield related performances characterizing masticatory functions in either tough or soft foods, but peanuts and raw carrots require much more effort than, say, cooked chicken or steamed vegetables, which is what many denture wearers eat.

Finally, there is no description of how the patients chewed—vertically or horizontally. Since the power of mastication for denture wearers is reduced by 75 percent, it is important to maximize the chewing efficiency by employing sharp posterior teeth and instructing patients to eat vertically.

Discussion and Recommendations

Which Concept on Occlusion Is Correct?

Gordon Christensen, in his annual review *New Directions in Dentistry*, stated: "There is extreme controversy about which concept of occlusion is correct, and I do not see any relief to that controversy."[46] In a subsequent article, he wrote that "the profession is in major chaos relative to occlusion."[47] Frank Spear recently wrote that "a byproduct of increased interest in occlusion has been a renewed debate about which occlusal philosophy is correct."[48]

Why is this question so difficult to answer? Because of the different interpretations of the word *occlusion*, we are not quite sure what the question is asking. If it is asking the best way teeth should touch each other and when, the answer would be that the contact should be confined to the tip of the cusps, and that contact should occur only during swallowing. If it is asking the best way teeth should touch each other during mastication, the answer would be that they shouldn't. If it is asking for the most efficient way the stomatognathic system should function, the answer would be: without heavy compressive vertical and lateral forces (DCS). But the question is not focused on *any* of these interpretations. What Christensen and Spear are referring to are the two different philosophies taught at the LVI and at the Pankey Institute: the neuromuscular methodology, on the one hand, and the gnathological approach, on the other. But wait a minute! These are not concepts on occlusion. These are two different methods of rehabilitation and/or reconstruction to be used when patients are in trouble. So now the word *occlusion* has a fourth interpretation.

Is one method better than the other? That is not the important question. What we should be asking is: What is the best way that general practitioners should be doing their work in order to minimize the deleterious effects of DCS so that patients don't have to go into rehabilitation? Why general practitioners? Because it is the GPs who are doing the vast majority of the work. Very few patients go into rehabilitation or reconstruction—probably less than 1%. The majority of dental work that is performed each day throughout the world is by increments—a crown here, an amalgam restoration there, facial composites, or some fixed bridgework. Since this is reality, what is the best way GPs can perform this incremental work, maintain the health and efficiency of the stomatognathic system, and prevent DCS? That is what we really want to know if we are going to interpret "concept on occlusion" objectively.

What are the guidelines? GPs should:

1. Be alert to the signs and symptoms of DCS.
2. Thoroughly explain DCS to their patients.
3. Determine if an equilibration is necessary.
4. Determine if a guard is necessary.
5. Mimic the natural design of teeth when delivering dental prostheses to the mouth.

Problem-Solving for TMJDs

When patients present with oral-facial pain and/or discomfort in the TMJ, dentists should consider that DCS might be the source of the problem. Traditionally, clenching and grinding have been the most agreed-upon cause of TMJD.[49] If this is confirmed either by the patient or by information gained by examining the dentition, the three-step management therapy described earlier should be initiated to reduce the stress on the TMJ.

If a patient's condyles have migrated down and forward, there are three traditional methods of management: (a) manually reposition the condyles and then equilibrate the dentition; (b) have the patient wear a splint (mandibular repositioner/deprogrammer) for a period of time and then equilibrate; and (c) use neuromuscular instrumentation. For GPs there is a fourth method that is simple and effective and produces immediate positive results: equilibration. If occlusal indicator wax is used to diagnose the occlusal contacts, it is common to see that, due to DCS, the mandible has worked its way forward and cannot return during swallowing or closure because the incline planes of the cusps are engaged. If this is the case, recreation of the intra-incline space will allow the condyles to resume their natural position.

DCS and Periodontal Disease

DCS can create periodontal disease through a disturbance of the physiology. Firestone and Miller demonstrated how DCS can produce changes in salivary composition, blood calcium levels, and extreme alveoloclasica.[50]

DCS and Oral Implant Patients

As with natural dentition, there has been an ongoing controversy about occlusion in implant therapy. The primary concern is the durability and life span of the prosthesis.[51] It is unfortunate that with implant therapy, the only question regarding occlusion that implantologists seem to be concerned with is when the implant should be loaded. Instead, they should be more concerned with the source, frequency, and power of that load. There are two power sources of loading: mastication and DCS. During mastication, the loading that is introduced through the bolus of food is not directed down the implant's long axis but rather distributed at various levels of the prosthesis, implant body, and surrounding bone in the form of complex bending movements.[52] However, this seems to be of little concern, since the power source is only about 60 pounds per square inch. The loading we *should* be concerned with results from the vertical and horizontal components of DCS, which can exceed 300 pounds per square inch.

When planning implant reconstruction, the restorative dentist must consider that the loss of the patient's natural dentition may have been due to DCS, which will probably jeopardize the integrity of the newly placed implants. Complications from DCS for implant-supported prostheses include acrylic and porcelain veneer fractures, abutment or prosthetic screw loosening, fracture of prosthesis and implant body, and crestal bone loss.[53] With these complications in mind, what guidelines should oral implantologists follow to minimize heavy compressive forces? During the consultation phase, patients should be questioned about their awareness of DCS. If patients are semi-edentulous, their remaining dentition will reveal valuable information. Thus, their remaining teeth should be evaluated to determine if a reduction of the working cusp inclines might be beneficial.

Oral implantologists have to create the best defense against heavy compressive forces. This is accomplished not only by establishing a strong implant foundation but also by minimizing the effects of DCS by stress reduction and guards. Since at this time there is no way the surface-to-bone interface of an implant can compare to its natural predecessor, it is imperative that implantologists maximize the interface by using larger and/or additional implants in high-quality bone sites.[54] Sharp occlusal anatomy and vertical loading during closure are mandatory. Finally, guard protection while sleeping is good insurance.

The subject of occlusion has been made more complicated than it has to be. It seems that we are trying to explain everything by the way teeth come together, whereas the most comfortable patients always have their teeth apart. The occlusion confusion has distracted dentists from focusing on the more serious problem of patients grinding and clenching their teeth. Would we have any problems related to occlusion if patients did not clench and grind? I think very few. The first line of defense for TMJD and oral facial pain is the GP's understanding of the relationship between occlusion, the stomatognathic system, and DCS prevention.

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