Occlusion: What It Is and What It Is Not

Charles McNeill, DDS

ABSTRACT

Dental occlusion is much more than the physical contact of the biting surfaces of opposing teeth or their replacements. Occlusion is more comprehensively defined biologically as the coordinated functional interaction between the various cell populations forming the masticatory system as they differentiate, model, remodel, fail, and repair. Morphologic variations are very common and represent the norm. Even though the occlusal or musculoskeletal relationship may not meet the definition of the clinician's concept of an optimum or ideal occlusion, it must be appreciated that for that particular patient, the tissues of the masticatory system may have developed a stable, functional, healthy, and comfortable equilibrium. However, when the functional equilibrium is perturbed or when the occlusion is being re-established, specific treatment criteria are as important today, if not more important with the rapid growth of implant placements, as ever before. Treatment of the occlusion should be considered on an individual basis based on the specific physiologic needs of the various tissue systems within the masticatory system rather than on a preconceived, stereotyped or universal basis. It has long been established and recently proven that proper management of the occlusion is directly correlated to the successful treatment and maintenance of the teeth and, at times, the supporting tissues. On the other hand, it has not, to date, been scientifically proven that occlusion is directly correlated to the musculoskeletal disorders that affect the jaw (temporomandibular joint or masticatory muscle disorders).

Occlusion is not a static, unchanging structural relationship, but rather a dynamic, viable physiologic relationship among the various tissue systems.

Occlusion is most appropriately defined as the functional relationship between the components of the masticatory system including the teeth, supporting tissues, neuromuscular system, temporomandibular joints, and craniofacial skeleton.[1] The masticatory tissue systems function in an integrated and dynamic manner in which stimuli created by function signal tissues to differentiate, model, and remodel. The behavior of the cell populations in these tissue systems is determined by the biological environment. When there is a perturbance to this dynamic functional equilibrium due to injury, disease, adverse functional demands, or a loss in the adaptive capacity of the tissues, tissue failure can occur. However, the cell populations of the various masticatory tissue systems have great potential for physiologic repair, reducing the demand for treatment. Thus, occlusion should be defined physiologically not morphologically. Occlusion should not be defined simply, as in most dictionaries, as any contact or relationship between the incising or masticating surfaces of the maxillary and mandibular teeth and/or dental arches.[2] Occlusion is not a static, unchanging structural relationship, but rather a dynamic, viable physiologic relationship among the various tissue systems. When this viable equilibrium is disrupted or injured, the resulting occlusal discrepancies can adversely affect the teeth and, at times, the supporting periodontal tissues. However, occlusal discrepancies, especially ones that have developed over time, have not been proven to be the cause of musculoskeletal disorders affecting the jaw. Conversely, occlusal discrepancies can be the effect of a jaw disorder, for example, osteoarthritis of the tempormandibular joint causing a collapse of the posterior occlusion on the affected side.

Occlusal Classification

Occlusion can be classified into three general types of physiologic stages as follows:[1,3-5]

- A physiologic occlusion commonly termed a "normal" occlusion suggesting that disease and/or dysfunction are not present and treatment is not required;
- A nonphysiologic occlusion, commonly referred to as a "traumatic" or "pathologic" occlusion suggesting that limited disease and/or dysfunction is present and treatment may be required; and
- A treatment occlusion often referred to as an "ideal" or "therapeutic" occlusion suggesting that specific treatment criteria are required to treat the effects of trauma or disease.

An integrated diagnostic rationale based on an adequate collection of information from the patient's history, clinical examination, and other indicated tests is required to appropriately categorize and manage the three different types of occlusion.

Physiologic Occlusion

A physiologic occlusion is defined as an occlusion in which a functional equilibrium or state of homeostasis exists within the tissues of the masticatory system. The biologic processes and local environmental factors are in balance. The stresses acting on the teeth are dissipated normally with a balance existing between the stresses and the adaptive capacity of the supporting tissues, masticatory muscles, and TM joints. This type of occlusion is typically found in the healthy, comfortable patient who does not require dental treatment even if the occlusion itself does not present morphologically as a theoretical ideal occlusion. A physiologic occlusion can present as a number of disparate structural variations but, in a given individual, represents an acceptable functional occlusal relationship.

To maintain a physiologic equilibrium, the masticatory tissues continually adapt throughout life to various internal biologic factors and external environmental factors as well as time-dependent changes. Physiologic variations in dental and skeletal relationships typically occur slowly, over time, during growth or as acquired variations that have had sufficient time to allow for tissue adaptation. The fibrous connective tissues and underlying mesenchymal layers of the TMJ are particularly capable of adaptation by continual progressive and regressive remodeling.[6] Studies have shown strong evidence that the potential for tissue repair following insults is much greater for the TMJ than other synovial joints whose articular surfaces are composed of hyaline cartilage (**Figure 1**).[7,8] Also, the natural capacity for muscle adaptation allows for changes in muscle tone, in the number of sarcomeres, in connective tissue apposition at the muscle-tendon interface, in the muscle fiber direction, and in the migration of muscle insertions.[9] At the occlusoradicular level, slight to moderate tooth wear (age dependent), limit-

ed physiologic mobility, and even minor tooth repositioning are forms of adaptation (**Figure 2**).

Inappropriately, the term "malocclusion" is used sometimes to imply a nonphysiologic occlusion and/or a need for occlusal treatment. Malocclusion implies that the occurrence of occlusal variation is in itself disease. But many so-called malocclusions are essentially morphologic variations that are judged against normative population means.[10] It has been estimated that approximately 95 percent of the population has some form of a malocclusion, i.e., crowding, malalignment, or structural abnormality.[11] In fact, a developmental morphologic variation without evidence of tissue pathology is actually a physiologic adaptation to a combination of intrinsic and extrinsic factors. The resulting functional equilibrium that ensues becomes the most physiologic relationship for that particular individual.

Occlusion is not and should not be defined by rigid, stereotyped structural ideal relationships that are theoretically required for optimum health, function, and comfort. It is quite evident that the tissues of the masticatory system are extremely capable of adapting to their environment, and extreme caution and care must be taken before this functional equilibrium is clinically altered. On the other hand, if the equilibrium shifts toward a nonphysiologic state due to loss of function from adverse loading including parafunction, by a loss of the capacity to adapt, or from disease, then the occlusal category could change to a nonphysiologic occlusion.

Nonphysiologic Occlusion

A nonphysiologic occlusion is defined as an occlusion in which the tissues of the masticatory system have lost their functional equilibrium or hemostasis in response to the functional demand, injury, or disease. The masticatory tissues are biologically distressed and unable to adapt to the environmental factors acting on the system and/or the functional demand exceeds the adaptive capacity of the system. Pathologic changes can result from sudden or abrupt insults or from loading of sufficient magnitude or duration that there is insufficient opportunity for tissue adaptation. These sudden, disruptive changes can be caused by trauma including parafunction, inflammation, or disease and, at times, from iatrogenic causes[12] (**Figures 3 and 4**). Tissue systems begin to fail and unless the direction of the functional

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equilibrium repairs itself, treatment is usually required. Based on tissue damage, pathology or dysfunction, the occlusion would be categorized as a nonphysiologic occlusion.

A nonphysiologic occlusion is directly related to dental health, or lack thereof, but not to musculoskeletal jaw disorders (TMD). Dental signs and symptoms related to a nonphysiologic occlusion include an uncomfortable, uneven, or "lost" bite; sensitive, painful, or sore teeth; worn, cracked, or broken restorations, teeth, roots, or implants; and abnormal tooth mobility, widened periodontal ligament, fremitus, tooth migration, and occlusion-related periodontal pain. However, occlusion has not been proven to be directly correlated to musculoskeletal conditions affecting the jaw (TMD) except for a weak association with a unilateral lingual cross-bite in children and those with five or more missing posterior teeth.[13] But, the studies associating loss of posterior support and TMJ degenerative changes reported that bruxism is a necessary additional contributing factor.[14,15] Also, the studies relating missing posterior teeth and articular degeneration did not address the confounding factor of age, making the association suspect.

To date, clinical studies have shown a negative association between dental attrition or parafunction and jaw disorders. Nor does the type of guidance contact (working, anterior, or canine guidance contacts) or working or nonworking contacts in laterotrusive jaw movements have any association with jaw disorders.[16] There is an association between occlusal variations of sufficient magnitude and musculoskeletal jaw disorders, but it is not typically a causal one. The associated significant occlusal variations are a severe skeletal anterior open bite (overjet greater than 6 to 7 mm). and a discrepancy of greater than 2 mm between the centric relation or retruded contact position and the intercuspal position.[17] However, it is important to point out that association does not prove cause and effect; and, in fact, open bite and asymmetrical retruded contact position-intercuspal position (RCP-ICP) discrepancies are usually the effect of jaw disorders rather than the cause.[18]

Treatment Occlusion

Treatment of the occlusion should be considered on an individual basis based on the specific physiologic needs of the various tissue systems within the masticatory system rather than a preconceived, stereotyped concept. Treatment of the occlusion includes occlusal adjustment of a single tooth to a full-mouth adjustment or equilibrium, restorative therapy with a single restoration to a full-mouth rehabilitation, prosthodontic therapy including implant dentistry, and/or orthodontic therapy including orthognathic surgery. In general, the goals are the same for all treatment approaches: Restore anatomical form by restoring or replacing missing structure; establish structural stability by optimizing the force distribution; and provide functional harmony for mastication, deglutition, and speech. The rationale for treatment is to improve dental health, function, comfort, and esthetics.

Occlusal treatment is indicated for the following dental conditions: pulpal and periodontal sensitivity; progressive tooth mobility and/or lack of stability (i.e., lack of proximal contacts, tooth extrusion or migration); poor alignment, crowding, or rotations of the teeth; structural damage to the teeth (i.e., tooth fracture, chipping, abnormal wear, root resorption, and possibly abfraction); pericementitis, widened periodontal ligament, or related periodontal destruction; missing teeth; impaired masticatory function (i.e., mastication, swallowing, speech); and esthetic considerations.[19] Occlusal treatment is not indicated when there are concurrent problematic general or dental health conditions. If there is a lack of physical or emotional stability, lack of maxillomandibular or dental stability, or lack of interest, concern or compliance by the patient, occlusal treatment should not be instituted. Lastly, when there are complaints of pain including chronic pain syndromes, e.g., fibromyalgia, systemic pain, orofacial pain or dental pain, occlusal treatment is not indicated. Unfortunately, many theoretical, ideal occlusal treatment plans are stereotyped and are the same for every patient regardless of the diagnosis. The predetermined occlusal scheme is fabricated to treat all patients regardless of their functional needs or dental diagnoses. To superimpose the clinician's concept of an ideal structural and/or functional relationship on a particular patient is inappropriate.

Treatment Category

To plan the proper occlusal treatment required for a specific set of conditions, diagnostic decisions must be made first. The diagnostic decisions are based on the type and extent of treatment that needs to be performed; namely, whether to maintain, modify or re-establish the existing occlusal schema.[20] The three different treatment categories are determined by clinical judgment and are based on the individual structural

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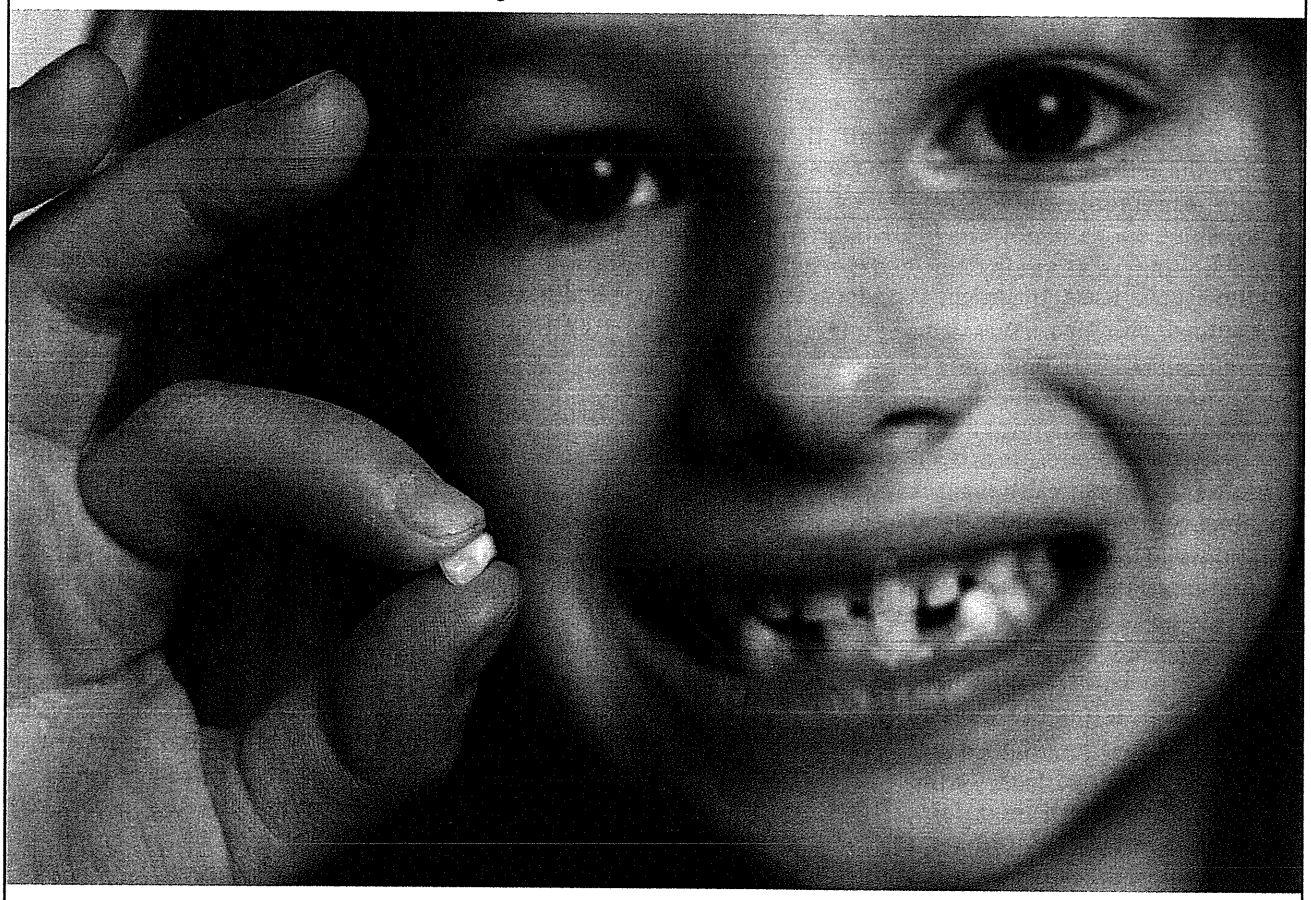

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and functional demands of the patient. Also consideration should be given to the clinician's training, skill, and experience as well as the patient's health, interests, and abilities when establishing the specific treatment category.

The decision to maintain the existing occlusion is based on the clinical findings that a functional equilibrium between the tissue systems has been established; and, thus, the resulting acceptable occlusion should be maintained. The intra- and interarch tooth relations, the intercuspal position (maximum intercuspation or centric occlusion), and the vertical dimension of the occlusion are acceptable. Great care should be exercised to maintain an acceptable functional equilibrium before changing it to meet some idealized theoretical concept. If a clinical decision is made to modify or re-establish the occlusion, there should be definite and substantial reasons to support the decision. Indeed, a modification classification is predicated on the fact that there needs to be some modification of the intra- and/or interarch relations, but not of the existing intercuspal position or vertical dimension of occlusion. They are deemed acceptable and, therefore, should be maintained. Whereas a re-establishment category is determined by the fact that there is not only a clinical need to re-establish or reorganize the intra-interarch relations but that the intercuspal position and/or the vertical dimension of the occlusion needs to be re-established as well.

If a clinical decision is made to modify or re-establish the occlusion, there should be definite and substantial reasons to support the decision.

Once the treatment classification has been determined, treatment planning and sequencing must be considered. Maintenance dentistry requires very little planning in that a limited number of restorations is simply introduced to an established, acceptable oc-

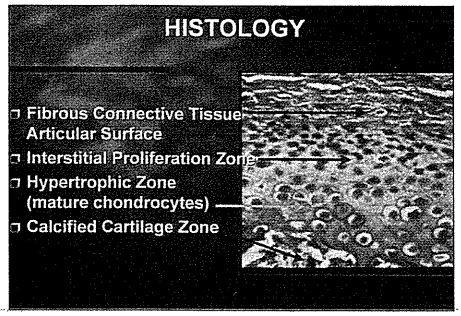

Figure 1. The different zones of cell populations covering the surface of the mandibular condyle as opposed to other synovial joints, which are covered by hyaline cartilage.

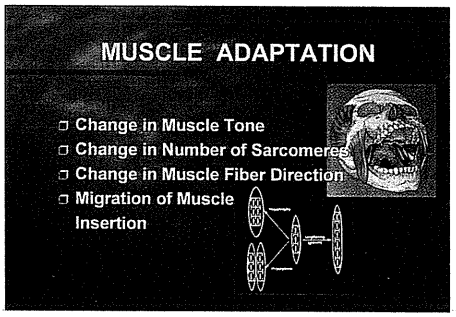

Figure 2. A list of possible mechanisms that allow for muscle adaptation.

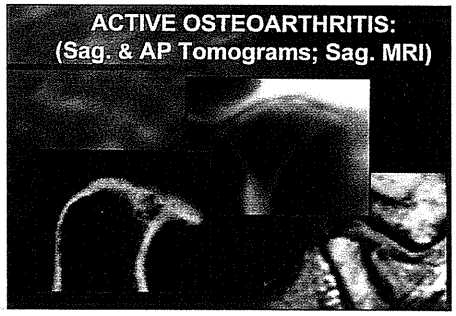

Figure 3. From left to right, sagittal and anterior-posterior tomograms and sagittal magnetic resonance image of active osteoarthritis in the TMJ resulting in possible sudden changes (supracontact) in the posterior occlusion on the same side.

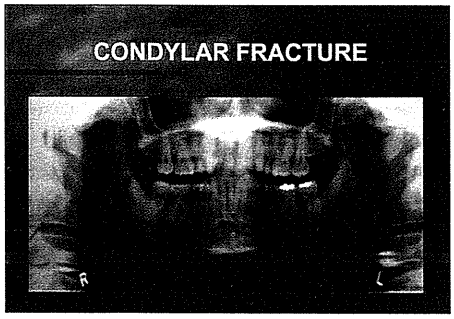

Figure 4. Panoramic view of a fractured right condyle resulting in a sudden, abrupt change in the occlusion.

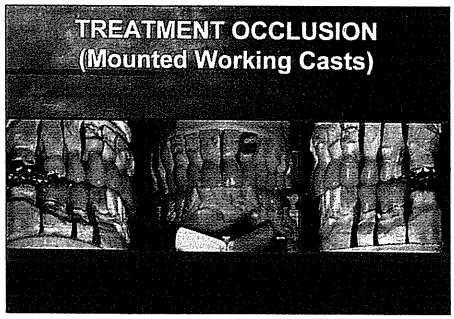

Figure 5. Working casts mounted in centric relation on an articulator during the laboratory sequence to facilitate returning the restorations to the patient's mouth in the treatment room using a reliable reference position.

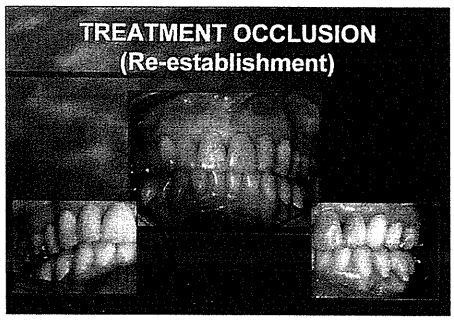

Figure 6. Restorations placed in the mouth aided by the centric relation reference position of the mandible (condyle) to the cranium.

clusal scheme. Whereas, the modification classification requires slight to moderate change or improvement, such as minor occlusal adjustment, tooth movement, or opposing tooth restoration or replacement, prior to accepting the original acceptable occlusal scheme. However, the re-establishment classification usually requires major changes to a clinically unacceptable occlusal scheme primarily associated with the need to establish a new intercuspal position and/or vertical dimension of the occlusion.

There are specific and rather precise technical requirements and clinical considerations involved when an occlusion scheme has to be re-established or reorganized. The newly re-established occlusal scheme does not benefit from time-related adaptation but, rather, must be integrated with and conform to the remaining tissues of the masticatory system. The jaw relationship must be stabilized and painful or pathological conditions treated prior to definitive occlusal therapy.[21] This requires careful attention to detail and proper treatment sequencing including possible pretreatment with an interocclusal appliance; prior ancillary treatment, i.e., endodontic, periodontic, or surgical treatment; and, at times, prolonged provisional treatment. Lastly, and very importantly, when re-establishing the occlusal scheme, a treatment reference position must be established. During maintenance and modification treatment, the reference position has, by definition, already been established by virtue of the fact that the intercuspal position and vertical dimension of the occlusion have been deemed acceptable and only need to be maintained. But when the intercuspal position and/or vertical dimension needs to be re-established, a new, reproducible reference position is required because, by definition, the original intercuspal position is no longer available or acceptable, e.g., orthodontic, orthognathic, complex restorative, or prosthetic/implant treatment (**Figures 5 and 6**).

Reference Positions

There are, in general, three jaw relations that are used clinically as reference positions: the intercuspal position (ICP), myocentric (MC) and centric relation (CR), or the retruded contact position (RCP).[1] The intercuspal position is clinically the most reproducible reference position. It is determined morphologically by the

shape and location of the teeth, by the periodontal sense organs through proprioception, and by muscle memory, which is reinforced by tooth contact. The sensory input allows the mandible to open and close rapidly and repeatably in the same position. When ICP is unacceptable, there are two alternative clinical approaches to establish a reproducible reference position. Either a joint-ligamentous dictated position, CR or RCP, or a muscle-dictated position, MC, can be used reliably to relate the mandible to the cranium on a relative reproducible basis. Variations of a muscle-dictated jaw relationship determination using either tongue, speech, or rest position, or voluntary repeated mandibular closures are reported in the clinical literature but are not easily standardized and, therefore, will not be presented.

Myocentric

The MC reference position is obtained through the use of transcutaneous electrical neural stimulation creating a neuromuscularly oriented occlusal position.[22] The theory is that the stimulation from surface electrodes placed over the sigmoid or mandibular notch stimulates the motor root of the trigeminal nerve and the facial nerve with an "all or none" motor response and is, therefore, reproducible. Studies suggest that the stimulation acts only in the periphery without the participation of the central nervous system as reported by the manufacturer.[23] Nonetheless, clinicians have developed techniques with the use of electrical stimulation of the facial and some masticatory muscles that by their report provide a reproducible and acceptable mandibular position. This approach must account for variations in muscle tone throughout the day with changes in activities of daily living, various emotional states, posture, and fatigue.

Centric Relation

The definition of centric relation keeps changing in the literature. Conceptual approaches to the definition of centric relation can be anatomic, orthopedic, or operational. The anatomical definition is the traditional dental concept of the optimum structural relationship of the mandible to the cranium. One of the seven anatomical definitions published in the seventh edition of the "Glossary of

Prosthodontic Terms" is as follows: "The maxillomandibular relationship in which the condyles articulate with the thinnest articular portion of their respective discs in the anterior-superior position against the posterior slope of the articular eminentia."[24] The orthopedic definition is based on the physical medicine concept of a closed-pack relationship of articular structures as determined by function. The condyle would be "seated" in the fossa with an interposed articular disk, if not compromised, as determined by the mandibular muscles during function, i.e., the compression or functional loading of the articular structures during chewing and swallowing. The closed-pack relationship of articular structures in any joint is considered to be both physiological and biomechanically stable. Because tomographic surveys of nonsymptomatic subjects have shown great variation in condylar position, this functional definition may be more accurate than the first one, which is based on anatomical relationships that cannot be validated. The third and more operational definition is based on the concept that in order to perform precise, complex occlusal treatment, it is technically advantageous to use a reproducible border position of the jaw.[1]

CR or RCP is independent of tooth contact and is determined by manipulation of the mandible in a rotary movement about a transverse horizontal axis.[25] The operational significance of CR is that it allows the clinician to evaluate the progress and outcome of the treatment based on a definite starting and ending point. One clinical advantage of the hinge axis is that technically the patient's horizontal axis of closure can be transferred to an articulator allowing for the possibility of alterations, within limits, of the vertical dimension of occlusion. The mandible is manipulated in a retruded direction while being supported in a superior direction at the gonial angles to allow the condyles to be braced in the most anterio-superior direction against the posterior slopes of the eminentia.[26] Techniques must be altered after condylar fracture, bony degeneration, and soft tissue alterations because the structural components that originally provided for a physiologic position of the condyle are no longer available. The patient may have to be in a more

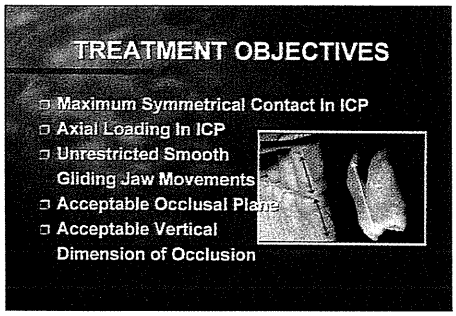

Figure 7. Treatment objectives.

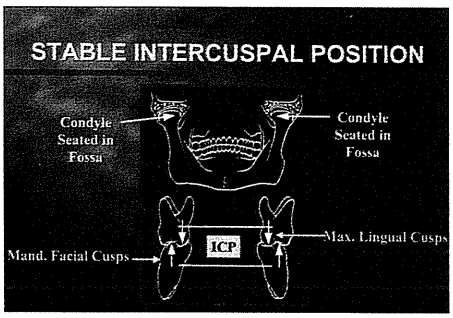

Figure 8. Stable intercuspal position of the condyles within the fossae and cusp fossae contacts of the opposing teeth.

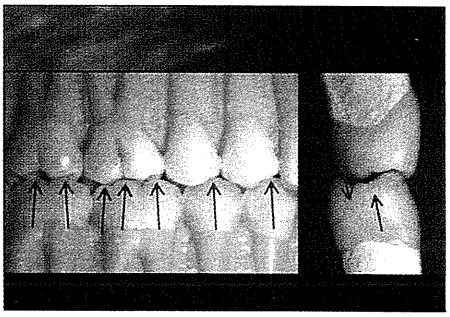

Figure 9. Centric stops allowing occlusal loading forces to be directed axially.

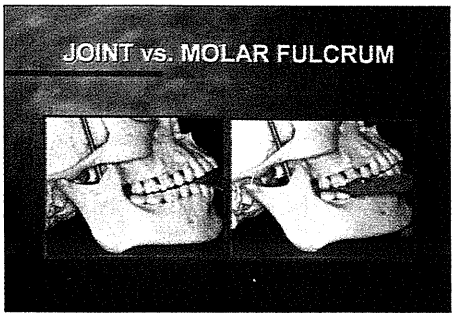

Figure 10. Placement of a shim in the anterior tooth region results in the condyle becoming more seated superiorly or in the most posterior tooth region results in a possible distraction of the condyle.

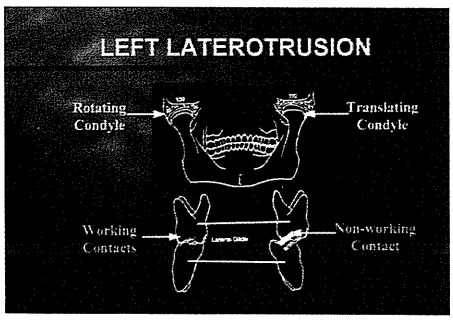

Figure 11. Left mandibular laterotrusion resulting in rotation of the left condyle and translation of the right condyle and working guidance contacts on the left teeth and nonworking contacts on the right side. Note: If tooth contacts are not deflective, the contacts by themselves are not detrimental to smooth gliding movements of the mandible.

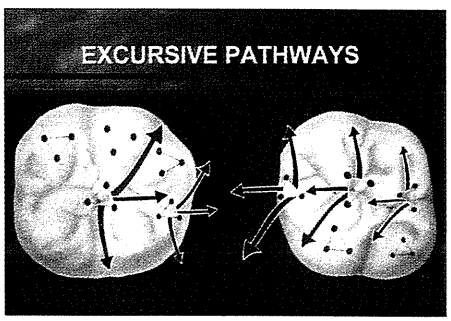

Figure 12. Excursive pathways during working, nonworking, and protrusive mandibular movements allowing for smooth gliding movements of the mandible.

There appears to be no scientific evidence to support one occlusal scheme over the other, and a wide variety of contacts are found naturally.

upright position with gentle manipulation directed more superiorly than posteriorly and with the patient aiding the closure. Thus, technique and experience become critical, but it has been shown that this approach can become clinically replicated.[27]

Specific Treatment Objectives

Once the treatment category has been determined, specific clinical objectives need to be established to develop optimum dental health (**Figure 7**). The specific objectives that are suggested from a optimum functional standpoint include:

- Maximum symmetrical distribution of the centric contacts in the intercuspal position (which may be in CR, depending on the treatment category);
- Axial or near axial loading of the teeth;
- An acceptable occlusal plane;
- Guidance contacts allowing for freedom without deflection in closing and excursive gliding mandibular movements; and
- An acceptable vertical dimension of occlusion and interocclusal resting range.[1]

Even distribution of tooth contacts in the intercuspal position is desirable to establish maximum stability and optimum distribution of the closing forces (**Figure 8**). The natural number of ICP contacts averages approximately seven bilateral contacts, with the molars loaded more than the premolars, which are loaded more than the cuspids.[28] If the location of the occlusal load occurs only in the most distal molar region, specifically the third molar and possibly in the second molar region, it may act as a deflective contact causing the ipsilateral condyle to become unloaded (distracted) with the contralateral condyle undergoing increased compression (**Figure 9x**).[29]

Axial loading of the teeth (**Figure 10x**) in a slight mesial direction allows the reaction forces on closure or during clenching to be transmitted vertically rather than laterally along or near to the long axes of the teeth. Vertical loading forces are better accepted by the viscoelastic periodontal ligament than horizontal forces.[30] Nonaxial loading generates mechanical moments or torquing forces at or near the alveolar crest of supporting bone. Axial loading of dental implants is even more critical because of decreased proprioceptive input as a consequence of investing bone rather than the periodontal ligament.[31]

The plane of occlusion is defined as the average imaginary plane established by the incisal and occlusal surfaces of the teeth.[2] Because of the compensating anteroposterior and mediolateral curvatures of the teeth, the plane of occlusion is actually curvilinear. The angulation of the occlusal plane is on the average approximately 10 degrees higher or steeper than the Frankfort plane. The importance of these occlusal planes is their influence on cusp height and position and their relationship to tissues in the masticatory system.

Functional harmony is improved by providing unrestricted smooth gliding movements of the mandible. Excursive guidance contacts can be provided by one or more teeth, e.g., canine guidance, anterior guidance, or group-working guidance. There appears to be no scientific evidence to support one occlusal scheme over the other,[13] and a wide variety of contacts are found naturally. Functional harmony requires that tooth contact during mandibular movements be guiding ones as opposed to deflective contacts (**Figure 11**). Deflective contacts, also called premature or interceptive contacts, are defined as occlusal contacts that divert the mandible from a normal path of closure or interfere with normal, smooth, gliding mandibular movement and/or deflect the position of the condyle, teeth (analogues), or prostheses (**Figure 12**).

The vertical dimension of the occlusion is defined as the distance between two anatomical points, e.g., on the face or jaws, when the occluding members (teeth, bite blocks) are in contact.[2] The postural resting range usually is a 1 to 3 mm open position of the mandible relative to ICP. General body, head and neck posture, speech, sleep, age, stress, and pain all influence the postural resting range. Clinical rest position is not a position of minimal muscle activity but rather an upright postural position.[32] Patient accommodation to significant changes in vertical dimension of the occlusion suggests that it is not immutable but can be modified within reason without clinical consequence.[33]

Conclusion

In the past, the dental literature in the field of occlusion was primarily based on clinical observations, case reports, and testimonials. Technical bias drove treatment rather than scientific knowledge in many cases. However, today there is a definite momentum within the dental profession to move from a clinically based position to an evidenced-based position in the field of occlusion. The scientific literature's questioning of the association between occlusion and musculoskeletal jaw disorders does not invalidate the well-established association between occlusion and dental health.[34] However, it is difficult to prove cause and effect between the

relationship of occlusion and the health of the masticatory system due to the lack of scientifically established criteria for an optimum treatment occlusion. Also, there still is a lack of knowledge regarding the natural history of the various occlusal relationships; and the large number of possible contributing factors make the confounding factors extremely difficult to control in clinical trials.

The same requirements for proper occlusal therapy are as valid today as in the past. Because implants do not have a forgiving periodontal ligament with special protective senses, the need for more precise occlusal treatment becomes even more critical. Until more evidence is established, treatment of the occlusion should be individualized to meet the patient's needs based on today's evidence and not on a clinician's belief system of an optimum structural relationship for its own sake. Treatment of the occlusion should only be considered when there are clinical signs and/or symptoms within the masticatory system that can be definitively related to the dysfunctional and pathological conditions of the various tissue systems. Treatment plans need to be modified based on the patient's abilities, desires, compliance, health, and emotional status in addition to the clinician's abilities, training, and experience. The cardinal rule should be to proceed carefully with treatment of the occlusion using the least invasive procedure as much as possible with all the skill and expertise possible. Treatment of the occlusion is essential to, and a requirement for, appropriate professional dental care; it is rarely essential to, or a requirement for, the management of musculoskeletal disorders affecting the jaw (TMD). CDA

Author / Charles McNeill, DDS, is a professor of clinical dentistry and director of the Center for Orofacial Pain at the University of California at San Francisco School of Dentistry.

References / 1. McNeill, C, Fundamental treatment goals. In, McNeill, C, ed, *Science and Practice of Occlusion*. Quintessence Publishing, Chicago, 1997, pp 306-22.

2. Zwemer TJ, ed, *Boucher's Clinical Dental Terminology*, 3rd ed. CV Mosby, St Louis, 1982, p 203.

3. Okeson JP, *Management of Temporomandibular Disorders and Occlusion*, 3rd ed. Mosby-Year Book, St Louis, 1993, pp 109-26.

4. Mohl ND, Diagnostic rationale. In, Mohl ND, Zarb GA, et al, eds, *A Textbook of Occlusion*. Quintessence Publishing, Chicago, 1988, pp 179-84.

5. Ramfjord SP, Ash MM, *Occlusion*, 3rd ed. WB Saunders, Philadelphia, 1983, pp 164-6 and 188-218.

6. Moffett B, Classification and diagnosis of temporomandibular joint disturbances. In, Solberg WK, Clark GT, eds, *Temporomandibular Joint Problems: Biologic Diagnosis and Treatment*. Quintessence, Chicago, 1980, pp 21-31.

7. Rasmussen C, Temporomandibular arthropathy, clinical, radiologic, and therapeutic aspects with emphasis on diagnosis. *Int J Oral Surg* 12:365-97, 1983.

8. deLeeuw R, Boering G, et al, Clinical signs of TMJ osteoarthrosis and internal derangement 30 years after nonsurgical treatment. *J Orofac Pain* 8:18-24, 1994.

9. Palla S, Occlusal consideration in complete dentures In, McNeill, C, ed, *Science and Practice of Occlusion*. Quintessence Publishing, Chicago, 1997, pp 457-67.

10. Bjork A, Krebs A, Solow B, A method for epidemiologic registration of malocclusion. *Acta Odontol Scand* 22:27-41, 1964.

11. Profitt WR, Epker BN, Ackerman JL, Systematic description of dentofacial deformities: the database. In, Bell WH, Profitt WR, White RP, eds, *Surgical Correction of Dentofacial Deformities*. WB Saunders, Philadelphia, 1980, Vol 1, pp 105-54.

12. Kampe T, Hannerz H, Strom P, Five-year follow-up of mandibular dysfunction in adolescents with intact and restored dentitions: a comparative anamnestic and clinical study. *J Craniomandib Disord Facial Oral Pain* 5:121-8, 1991.

13. McNamara JA, Seligman DA, Okeson JP, Occlusion, orthodontic treatment, and temporomandibular disorders: A review. *J Orofacial Pain* 9:73-90, 1995.

14. MacDonald JWC, Hannam AG, Relationship between occlusal contacts and jaw-closing muscle activity during tooth clenching: Part I. *J Prosthet Dent* 52:718-29, 1984.

15. MacDonald JWC, Hannam AG, Relationship between occlusal contacts and jaw-closing muscle activity during tooth clenching: Part II. *J Prosthet Dent* 52:862-7, 1984.

16. Kahn J, Tallents RH, et al, Prevalence of dental occlusal variables and intra-articular temporomandibular disorders: Molar relationship, lateral guidance and nonworking side contacts. *J Prosthet Dent* 82:410-5, 1999.

17. Pullinger AG, Seligman DA, Quantification and validation of predictive values of occlusal variables in temporomandibular disorders using a multifactorial analysis. *J Prosthet Dent* 83:66-75, 2000.

18. Seligman, Pullinger AG, Analysis of occlusal variables, dental attrition and age for distinguishing healthy controls from female patients with intracapsular temporomandibular disorders. *J Prosthet Dent* 83:76-82, 2000.

19. Wise MD, *Failure in the Restored Dentition: Management and Treatment*. Quintessence Publishing, London, 1995, pp13-147.

20. Braly BV, Occlusal analysis and treatment planning for restorative dentistry. *J Prosthet Dent* 27:168-71, 1972.

21. Dyer EH, Importance of a stable maxillo-mandibular relationship. *J Prosthet Dent* 30:241-51, 1973.

22. Jankelson B, Neuromuscular aspects of occlusion. In, Boucher LJ, ed, Occlusal articulation. *Dent Clin N Am* 23:157-68, 1979.

23. Dao TTT, Feine JS, Lund JP, Can electrical stimulation be used to establish a physiologic occlusal position? *J Prosthet Dent* 60:509-14, 1988.

24. Academy of Prosthodontics, Glossary of prosthodontic terms, 7th ed. *J Prosthet Dent* 81:39-110, 1999.

25. McNeill C, The optimum temporomandibular joint condylar position in clinical practice. *Int J Perio Rest Dent* 5:53-76, 1985.

26. Becker CM, Kaiser DA, Schwalm C, Mandibular concentricity: Centric relation. *J Am Dent Assoc* 83:158-60, 2000.

27. Wood DP, Elliott RW, Reproducibility of the centric relation bite registration technique. *Angle Orthod* 64:211-221, 1994.

28. Korioth TWP, Number and location of occlusal contacts in intercuspal position. *J Prosthet Dent* 64:206-10, 1990.

29. Hylander WL, An experimental analysis of temporomandibualr joint reaction force in Macaques. *Am J Phys Anthrophol* 51:433-56, 1979.

30. Caffesse RG, Fleszar TJ, Occlusal trauma. In, Wilson TG, Kornman KS, Newman MG, eds, *Advances in Periodontics*. Quintessence Publishing, Chicago, 1992, pp 205-25.

31. Wismeijer D, van Waas MAJ, Kalk W, Factors to consider in selecting an occlusal concept for patients with implants in the edentulous mandible. *J Prosthet Dent* 74:380-4, 1995.

32. Rugh JD, Drago CJ, Vertical dimension. A study of clinical rest position and jaw muscle activity. *J Prosthet Dent* 45:670, 1981.

33. Rivera-Morales WC, Mohl ND, Relationship of occlusal vertical dimension to the health of the masticatory system. *J Prosthet Dent* 65:547-53, 1991.

34. Clark GT, Tsukiyama Y, et al, Sixty-eight years of experimental occlusal interference studies: What have we learned? *J Prosthet Dent* 82:704-13, 1999.

To request a printed copy of this article, please contact / Charles McNeill, DDS, Box 0758, UCSF School of Dentistr10, 707 Parnassus Ave., San Francisco, CA 94143-0758 or at mcneill@itsa.ucsf.edu.