Occlusion-Based Treatment Planning for Complex Dental Restorations: Part 2

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Part 1 of this article discussed the rationale for a thorough occlusal evaluation of all patients requiring dental care. Those patients in need of complex reconstruction frequently require modification of one or more of six inter-related elements that comprise an occlusal scheme. Two of these elements, the centric relation position of the mandible and the vertical dimension of occlusion, were discussed. This article will continue the discussion of the remaining elements, beginning with the posterior plane of occlusion. The position and function of the maxillary incisal edges, as well as those of the mandibular incisal edges, will then be reviewed, followed by a consideration of posterior dental occlusal anatomy. These six elements dictate the function and esthetic nature of the final prosthesis, and their successful integration enhances the long-term prognosis of the reconstruction. (Int J Periodontics Restorative Dent 2003;23:325–335.)

Careful evaluation of the occlusion of patients requiring restorative care is a prerequisite to undertaking any restorative procedures. Patients with significant dental problems requiring complex restorative and surgical procedures may be more predictably managed if a preestablished sequence of occlusal evaluation and construction is used. Part 1 of this article reviewed the significance and relevance of the centric relation position of the mandible and the vertical dimension of occlusion (VDO).

Plane of occlusion

Following assessment of the mandibular centric relation position and the VDO through mounted study models, the next component of the occlusion to be evaluated is the posterior plane of occlusion. The occlusal plane is “the average plane established by the incisal and occlusal surfaces of the teeth.”1 This plane, the dental arches, and teeth have a specific relationship to the temporomandibular joints (TMJ) and to the horizontal plane. Correct

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positioning of the models on an articulator, which replicates these relationships in the patient, is a prerequisite for the functional and esthetic success of the prosthesis. When seen from the sagittal view in the average patient with no missing, supraerupted, or excessively worn teeth, the occlusal plane is at an angle approximately 10 to 15 degrees divergent from and inferior to the axis-orbital plane. It nearly parallels the ala-tragus line and has a slight inclination to the horizontal when the patient is standing upright.

The axis-orbital plane is “the horizontal plane established by the transverse horizontal axis of the mandible, with a point on the inferior border of the right or left orbit (orbitale).” This is the horizontal reference plane to which many articulator systems relate the maxillary models when a facebow is used in the mounting procedure. This plane, however, does not correspond with the true horizontal plane of the skull when the head is positioned upright. Its anterior portion is inclined apically, in a cranial direction. Therefore, use of this plane as a reference and transferring it back to the articulator results in dropping down of the anterior portion of the plane as it is made parallel with the horizontal upper member of the articulator. This results in an abnormally steep angle to the occlusal plane when the models have been mounted on the articulator, and it makes the transfer of critical esthetic information to the laboratory technician much more difficult.

To facilitate the transfer of this information, some manufacturers have created a facebow that uses an anterior reference point, which creates a plane that is inferior to the axis-orbital plane and closer to the midfacial horizontal plane of the patient. This places the plane of reference, which is now based on the actual horizontal plane, parallel to the upper member of the articulator, making an accurate transfer of the relationship of the patient’s occlusal plane to the horizon possible. A similar modification may be required for orientation of the occlusal plane in the frontal plane. This involves making the frontal member of the facebow also level with the horizon. The interpupillary line is frequently used as a reference; however, this is useful only if the eyes are truly level with the horizon. In those cases where they are not, other techniques have been suggested to accurately transfer this information to the articulator.

As the maxilla is the foundation of the occlusal plane, the maxillary posterior plane of occlusion will have definite implications in the design and function of the occlusion for the reconstructed patient. Consequently, tooth shape or position may need to be modified within this arch before the two arches may be related together (Fig 1). The position of the posterior teeth must be established prior to creating a physiologic anterior guidance. There are two functional requirements of a proper plane of occlusion, as described by Dawson. The plane must allow the anterior teeth to function to disclude the posterior teeth in protrusive movement, and it must allow disclusion of all teeth on the balancing side when the mandible moves laterally. To facilitate the establishment of these functional objectives of the restored occlusion, an occlusal plane that is as level as possible should be created. The posterior determinants of occlusion, the temporomandibular articulations and their associated structures, partially determine how quickly the posterior teeth separate when the mandible moves from the centric relation position. The more angled those surfaces, the more rapidly the posterior teeth separate. Conversely, the more shallow those angles, the less separation is demonstrated by the posterior teeth. However, the plane of occlusion will also affect the separation of the posterior teeth. Teeth uniformly positioned on a level occlusal plane will be separated much more rapidly during mandibular movement than teeth positioned on a curve or a plane that is excessively angled to the horizon and that more closely approximates the inclination of the condylar eminences. This is also true of teeth positioned in an arch that is very uneven because of missing, tipped, or supraerupted teeth. Rapid separation of the posterior teeth helps to preclude posterior interferences during mandibular movement. Consequently, no attempt is made to reestablish a curve of Spee or a curve of Wilson in the occlusion plane. The benefit of elimination of posterior excursive interferences far outweighs any benefit of increased chewing efficiency that
such an occlusal design ostensibly provides.

A third requirement of the plane of occlusion is that it must be esthetically positioned in the face. This determination must be made clinically, and the plane must be related to the facial esthetics of the patient. Provisional restorations that have been fabricated from a preoperative diagnostic wax-up are used for this procedure. The plane must be positioned at an appropriate vertical level so that there is adequate tooth display by the patient on smiling, and the patient must demonstrate adequate facial vertical dimension in maximum intercuspation. The final location of the occlusal plane, as part of the VDO, is a primary determinant for establishing an acceptable facial proportion and dimension. Finally, the occlusal plane should be parallel with the horizon when viewed from the frontal plane.

Treatment of esthetic problems of the anterior teeth is also directly dependent upon the relationship of these teeth to the plane of occlusion established by the posterior teeth. In the absence of developmental growth anomalies or extensive dental pathology, the posterior teeth will have erupted to the correct level in the face and established a reference plane to which the anterior teeth may be related. Esthetic treatment planning for anterior incisal plane discrepancies and eruption abnormalities begins by relating these teeth directly to the posterior occlusal plane. Therefore, the amount of deviation, if any, of the posterior plane of occlusion from the horizon will greatly influence treatment planning for those anterior tooth problems. Consequently, for both functional and esthetic purposes, the posterior occlusal plane must be evaluated and established initially as part of the reconstructive process.

Maxillary incisal edge position

In the intact and healthy Class I occlusion, the maxillary incisal edge position represents the anterior extension of the posterior occlusal plane. Consequently, a line extending anteriorly from the posterior occlusal plane, approximately parallel with
the ala-tragus line, will give a starting point from which the position of the maxillary incisor teeth may be judged. Conversely, should the posterior teeth be missing or the plane of occlusion be so deviated that it must be reestablished, posterior extension of a line from properly positioned incisal edges of the maxillary incisors, closely parallel with the ala-tragus line, will establish a plane to which the posterior teeth may be set in the reconstruction. There is obviously some variability in maxillary incisor edge position based upon esthetic and phonetic concerns. However, the posterior occlusal plane represents a good reference from which to begin the evaluation. Even though it is possible to reestablish the maxillary incisal edge position based primarily upon esthetic concerns, it must be remembered in many instances this is a purely subjective endeavor. As there is a range at which the incisal length may be established, the functional requirements of the incisors as the anterior determinant of occlusal function must not be overlooked.

In a mutually protected occlusion, mandibular elevator muscle activity is reduced in excursive movements through the contact of the anterior teeth. From a perspective of muscular activity, the ideal angle of anterior guidance is the shallowest one capable of clearly disclusing the posterior teeth. The shallower the angle of disclusion and the less muscle activity involved in the movement, the lower the horizontal forces that are placed on these teeth. The goal then is to establish a length of the incisors that satisfies the patient's esthetic requirements, yet will provide an overbite relationship that minimizes forces on the anterior teeth in excursions. Consideration of this concept begins during evaluation of the VDO of the patient. Increasing the VDO in the anterior segment of the mouth provides the opportunity to decrease the anterior overbite, which is of considerable value when maxillary anterior teeth must be lengthened for esthetics. However, as there is a range in what is considered to be an esthetic display of maxillary incisors, preference should be given to creating a final length that allows for the anterior guidance to be as shallow as possible, yet still leaves the patient with an esthetically pleasing result. This is particularly true of patients with weakened periodontal support, horizontal bruxism (Fig 2), or dental implants.

Esthetic treatment planning begins with locating the maxillary incisor position, and from there a
smile may be constructed. However, an average smile in young patients—exposure of the full central incisors—is not applicable to all patients, particularly middle-aged and older patients. All patients need not receive 11- to 12-mm central incisors, nor display the full central incisor on smiling. Different esthetic standards should be applied to patients of different age groups because of the effects of aging or variability of lip mobility. Therefore, the initial patient evaluation can suggest starting points for establishing anterior tooth length, overbite and overjet relationships, and the VDO. However, in reconstruction, these components are established, tested, and modified in the provisional restorations, which will ultimately be the blueprint for the final prosthesis. It is possible to achieve both a functional and esthetic result in reconstruction, assuming that one does not accept a “one look fits all” concept of anterior esthetics.

Mandibular incisal edge position

Initial consideration of mandibular incisal edge position also begins early in the diagnostic phase of treatment, when the VDO is assessed. Function of the mandibular incisors with the lingual inclines of the maxillary incisors will determine the type and amount of incisal guidance that will be established for the final restoration. This is a crucial decision, as the pathway of the anterior teeth is as important, if not more so, as the influence the TMJs have upon the functional occlusion of the dentition. An exceptionally steep incisal guidance may be relieved by an increase in the VDO and restoration of the lingual surfaces of the maxillary teeth. On the other hand, the VDO may be maintained, the incisal edges of the mandibular incisors reduced, and the lingual contours of the maxillary anterior teeth restored to reestablish contact and shallower guidance. In situations of inadequate incisal guidance, mandibular incisors and canines that are too worn to adequately function with the maxillary teeth must be restored.

Teeth that are out of position may require orthodontic therapy to place them into the proper relationship. In extreme instances, orthognathic surgery may be considered to position the mandibular teeth into a functional relationship with the maxillary teeth. These functional considerations, as well as phonetics and esthetics, dictate the incisal edge position of the mandibular anterior teeth.

After determining an appropriate position and length for the maxillary incisors, the position of the mandibular anterior incisal edges may then be developed. It is really not until all of these other elements of an occlusion have been evaluated and established that a nonarbitrary, functionally correct position for the mandibular incisors can be established. Contact of the mandibular incisors is best established on a small horizontal area, a few tenths of a millimeter in dimension, on the lingual surfaces of the maxillary anterior teeth. This directs the forces of occlusion more vertically than if the contacts were placed on an inclined plane. Movement from these small areas is onto angled surfaces contoured to minimize forces on the anterior teeth, yet they must clearly separate the posterior teeth in all excursions. McHorris has theorized that the angle of incisal guidance should be at least 5 degrees greater than the corresponding angle of condylar guidance to minimize potential protrusive interferences on posterior teeth. This represents a good starting point, and for many patients, this incisal guidance will be acceptable. For the average patient, this represents an angle of approximately 45 degrees. However, in reconstruction, posterior cusp height may be modified to accommodate the incisal guidance created.

Incisal guidance is customized for each individual patient, with different requirements for patients with different functional habits, and also for different patient types. For example, differences in chewing patterns must be accommodated in the final occlusal design. Patients with horizontal chewing strokes require a different type of guidance than those with vertical strokes. Patients with periodontally weakened anterior teeth have different requirements than those with healthy, stable periodontal support. Patients with uncontrolled bruxism habits or implant-supported restorations in the anterior segment also have their own occlusal requirements. These patients all typically require a shallower incisal guidance.
Additionally, patients not undergoing complete reconstruction, but merely receiving all-ceramic restorations for esthetic purposes, must also have a carefully established incisal guidance. Fractured restorations and postoperative sensitivity of teeth can frequently be related directly to the occlusion that has been established on them.

Because of their position in a class III lever situation, the anterior teeth are better suited to absorb occlusal forces than are weakened posterior teeth and must be allowed to do so. Many patients, particularly those with Class II malocclusion, will not demonstrate contact of anterior teeth; however, every effort should be made to establish contact. If this is not possible, there must be contact on at least the canines in centric relation. This provides the patient with a sense of stability to the occlusion and a starting point from which to begin and end excursive movements. In protrusive movement, the central and lateral incisors should mediate the separation of posterior teeth. There should be free and unstrained movement of the mandible and no fremitus noted on the maxillary incisors. A shallow angle of incisal guidance decreases horizontal forces on the anterior teeth as well as decreases muscle activity during the movement. As a means of distributing forces uniformly, all four incisors should be in contact throughout the excursion. With weakened anterior teeth, the canines may also be involved in the guidance. In those instances where the incisors are not in contact in centric relation, the initial segment of the protrusive movement must be mediated by the lingual inclines of the maxillary canines. A smooth and harmonious transition of the guidance must be maintained until the mandible has protruded far enough to establish contact of the incisal edges of the opposing incisors. In lateral excursion, the canines should be the primary mediator of the movement.

In the absence of maxillary canines, or when the canines and remaining anterior abutments are weak, it is necessary to establish a posterior group-function occlusal scheme using the posterior teeth for disarticulation. However, the anterior teeth should also be involved in the disarticulation, and excursive contact on the buccal cusps of the maxillary premolars and the first molars should diminish anteroposteriorly to minimize lateral forces on those teeth. Group-function occlusion is also desirable for patients with uncontrolled bruxism habits. These patients apparently do not have the benefit of a protective functioning anterior proprioceptive inhibition and can easily damage a crown or tooth upon which canine disarticulation has been established. Finally, this occlusal scheme is also desirable for patients whose canines have been replaced by dental implants. These patients will derive very little proprioceptive inhibition from implants placed in the canine location.

Anterior guidance must be established prior to finalizing the posterior occlusal contours, and the mandibular incisor edge position must be established before the lingual contours of the maxillary anterior teeth may be finalized. The maxillary and mandibular incisor contours are frequently established simultaneously, and this is done clinically while working out the excursive patterns in the provisional restorations. Anterior guidance is developed in harmony with each patient’s functional envelope of motion, in conjunction with neuromuscular requirements.

If a lack of anterior contact or an anterior open bite is the result of habit patterns, elimination of this habit would be part of the treatment goal. However, some habits, such as tongue thrusting, may not be readily resolved; therefore, restoration of mandibular anterior teeth must take this into account. Finally, the position and shape of the incisors are also tested phonetically when evaluating the patient’s ability to clearly make the sibilant sounds and evaluated esthetically. The plane should be horizontal for the best appearance and level with or slightly coronal to the mandibular posterior occlusal plane. The amount of mandibular incisor exposure during speech is dependent upon the age of the patient and may be modified accordingly within the dictates of occlusal function.

Occlusal surface morphology of posterior teeth

The final step in establishing an occlusion is the creation of occlusal
surface morphology for the posterior teeth. This exercise takes place in the laboratory; however, the clinician has the opportunity to affect the design through working with the provisional restorations. Accurately mounted study models of the final provisional restorations are transferred to the laboratory to aid the technicians in this task.

To adequately design posterior teeth, it is helpful to understand their functions. First, posterior teeth must support the VDO, which in turn protects the anterior teeth and the TMJs from overload. Second, the posterior teeth must function in mastication, and finally, to a certain extent, play a role in the esthetics of the final reconstruction. The posterior teeth must perform these functions and be designed so they do not interfere with the free and unstrained movement of the mandible as it functions through the incisal guidance that has been established (Fig 3). That is, they must not become occlusal interferences. If properly established, the forces of occlusion will be directed as nearly as possible down the long axes of the teeth. Lateral forces will be eliminated, or distributed to minimize the effect of forces within the system, and the restored posterior occlusion will demonstrate stability.

Of all aspects in establishing a physiologic occlusion, the design of the occlusal surface of the posterior teeth has been one of the most controversial areas over the years. As Taylor et al pointed out, there is still much debate concerning posterior cusp height, occlusal groove design and direction, and the nature of tooth-to-tooth contact itself. However, in the absence of evidence-based studies on the ideal occlusal morphology, empiric data from evaluation of long-term successfully treated cases by many different clinicians must be given serious consideration. These occlusions have been designed to perform their functions while promoting freedom of mandibular movement. They minimize muscular activity, thereby protecting the joints, teeth, and periodontium, and they distribute forces on the prosthesis as widely as possible. These requirements of a restored posterior tooth anatomy have all been described previously, yet the nature of the ideal static intercuspal position has not been described satisfactorily for all clinicians. However, if reduced to its most basic functional components, tooth-to-tooth contact must consist of only one point of contact per tooth, preferably a cusp against a flat area of the opposing tooth. This may be in either a fossa or on a marginal ridge; however, it may be more stable with contact of a cusp tip to the base of a shallow fossa. The area of contact need only be small, within 0.5 to 1 mm in diameter. This contact satisfies the first function of the posterior teeth—to maintain the established VDO.

Because of the position and angulation of the mandibular posterior teeth, it is desirable to have the buccal cusps of those teeth act as the centric holding contacts with the opposing maxillary teeth. Ideally, this directs the forces of occlusion through the long axes of both the maxillary and mandibular teeth. Because of the slight but measurable horizontal variability of the centric relation position of the condyles (within a few tenths of a millimeter range), an occlusal scheme with a single point and area of contact is easier to establish and adjust than one with multiple contacts per tooth, and it is comfortable to the patient. As there is also a wide range in the amount of immediate side shift of the mandible among patients, those patients with excessive side shift will require even greater occlusal adjustment and freedom to move from centric relation than those patients with no side shift. This occlusal scheme makes it easier to accommodate those patients as well.

The maxillary lingual cusps may or may not be used as centric holding cusps against the mandibular teeth. This determination is based upon the extent to which these palatal cusps act as balancing interferences when testing the occlusion in excursive movements. Because of the normal buccal inclination of the maxillary teeth, placing palatal cusp tips down completely into the central fossae of the mandibular molars frequently results in a cusp that hangs below the plane of occlusion, creating an unesthetic result and placing it in the path of a mandibular cusp tip during excursive movement. In the formation and adjustment of the occlusal scheme, these interfering cusp tips are shortened rather than deepening the opposing fossae or shortening the
mandibular buccal centric holding cusps. This occlusal anatomy has been advocated in the past, although it was usually on restorations with splinted teeth, particularly in the periodontal-prosthetic patient.\textsuperscript{11,27}

Although never demonstrated by research, the omission of the maxillary lingual cusps as centric holding contacts has been construed by many to contribute to a buccolingual instability of nonsplinted teeth. However, others\textsuperscript{32} have repudiated this notion of buccolingual instability and demonstrated that with proper anterior guidance and adequate mesiodistal stability, this occlusion design is as stable for restorations on single teeth as it is for splinted teeth. This is an important consideration for many patients, yet is of utmost importance for horizontal bruxers with intact periodontal support. These patients must be restored because of excessive tooth wear and do not require—in fact should not have—splinting of the restored teeth. The relatively flat restored occlusal scheme that these patients require nearly always results in the recontouring and shortening of the maxillary palatal cusps to clear the mandibular cusps in all excursive movements.

In reality, the major assets of this occlusion are its ease of design and adjustment and its overcompensation in preventing harmful posterior
Fig 3c (right) Final reconstruction. Dental implants are used to aid compromised teeth in supporting final maxillary prosthesis.

Fig 3d (below) Radiographic survey of final case.

Fig 3e Occlusal view of maxillary anterior and posterior tooth form demonstrates diminished but definite cusp height and shallowed anterior guidance to help protect teeth and implants.

Fig 3f Mandibular posterior tooth occlusal anatomy.

Fig 3g Strict attention to detail of occlusal design, shallow anterior guidance, and diminished posterior cusp form do not preclude an esthetic end result.
contacts, particularly balancing interferences. The construction of elaborate occlusal surfaces, with multiple contacts and tall cusps, to provide for “near miss” of opposing surfaces for an increase in chewing efficiency is unwarranted. The diets of patients requiring reconstruction do not require tall pointed cusps for mastication. In fact, the masticatory function of the posterior teeth has been compared to the action of a pestle and mortar in crushing and grinding of the food bolus.\textsuperscript{33} This occlusal scheme is uniquely designed to allow this function and thus satisfies the second function of the posterior teeth. The maxillary teeth attached to the base of the skull are stable and may be designed as a perfectly functioning mortar. The mandibular posterior teeth and buccal cusps are dynamic and function as very effective pestles.

Finally, in establishing posterior tooth form to enhance the esthetics of the final reconstruction, the maxillary buccal and lingual cusps may be established primarily on esthetic dictates, ie, their location on the occlusal plane, with the mandibular posterior tooth anatomy shaped to accommodate the maxillary teeth. The characteristics of the occlusal surface design for complex reconstruction, regardless of whether the teeth are splinted, may be summarized as follows:

1. The buccal cusps of the maxillary posterior teeth are positioned for esthetics on a level plane of occlusion, confluent with but slightly apical to the maxillary anterior teeth. Their contours may be modified, however, to accommodate the creation of a group-function occlusal scheme.
2. The maxillary palatal cusps may be placed into contact with the mandibular posterior teeth but are always adjusted to prevent the occurrence of balancing interferences in the final occlusal scheme. They should not be longer than the buccal cusps and may be shorter.
3. The maxillary and mandibular posterior teeth are formed with shallow central fossae.
4. The mandibular buccal cusps are positioned to direct occlusal forces as nearly as possible along the long axes of the teeth, preferably in contact within the central fossae of the maxillary teeth. They may, however, be in contact on marginal ridges of the maxillary posterior teeth.
5. The mandibular lingual cusps are positioned to prevent the tongue from being trapped on the occlusal surface, and because of the axial inclination of the teeth, they are shorter than the buccal cusps when viewed from the frontal plane.

As the elements of the stomatognathic system change with time following reconstruction, this design of occlusal anatomy provides the greatest ease in adjustment and variability to adapt to the changing environment. Changes in the joints, muscles, and teeth of a patient are inevitable, as is wear of enamel and restoring materials. Control of the occlusion helps to minimize these changes, and part of the recall program of every patient should consist of a regular and thorough evaluation of the occlusion.\textsuperscript{34} For many patients, periodic adjustment may be required, and this modified occlusal anatomy facilitates making and maintaining those adjustments.

**Conclusion**

A systematic evaluation of the occlusion of patients requiring complex dental procedures greatly facilitates the treatment planning process. During treatment, the systematic creation of a physiologic occlusion greatly enhances control of the reconstructive process through the completion of the prosthesis. Improved treatment planning and enhanced control of case completion ultimately increase the predictability of both, thereby increasing the long-term prognosis of the reconstruction. Establishing an occlusion is much more than designing the occlusal surfaces of posterior teeth. This historically controversial issue is but a small segment in a much larger and comprehensive undertaking. Through control of the entire occlusion, the practitioner is able to distribute forces and mediate the level of muscular activity, thereby controlling the load on the prosthesis, TMJs, and teeth themselves. Additionally, an evaluation of the various elements of an occlusion and their functional inter-relationships is also mandatory if an esthetic prosthesis is to be.
achieved. Concerns for the functional aspects of the occlusion and the creation of an esthetically successful prosthesis are not mutually exclusive, but in fact go hand in hand.

It is apparent that the occlusion must be mastered as part of the reconstructive process. Consequently, the team member who is responsible for constructing and maintaining the occlusion must take the lead responsibility in treatment planning and supervision of case completion. The success or failure of the restored occlusion will ultimately determine the long-term success of the reconstruction. Although there is not one occlusal scheme has proven to be successful in the reconstruction of all patients most susceptible to dental disease and destruction.

References