Bioesthetic Dentistry, Part 2

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This is part 2 of a 4-part article series. Part 1 of Drs. Hunt and Turk's article was published in the December 2011 issue of Dentistry Today *and can be found in our archived articles at dentistrytoday.com.*

INTRODUCTION

In part 1, the principles of Bioesthetic Dentistry and the preliminary diagnosis based on those principles were discussed. The restorative clinician's "engineering plan" to transform the worn and diseased dentition back to health is based on these principles. The preliminary occlusal diagnosis was made on patient models mounted in a centric related position of the condyles (not stabilized), evaluating both form and function in the patient's gnathic system.

The purpose of the present article is to describe the ideal form of the individual teeth of the human biological model (HBM) and present how that form creates a smooth comfortable functioning relationship between the maxillary and mandibular arches and the temporomandibular joint (TMJ) that protects the teeth and other oral structures from adverse forces during the act of occlusion (swallowing and mastication/chewing). The attention to the ideal form ensures not only longevity and comfort to the chewing system, but properly positions the teeth into the framework of the gingiva and lips to create a beautiful smile.

UNDERSTANDING THE BIOLOGICAL ROLE OF FORM

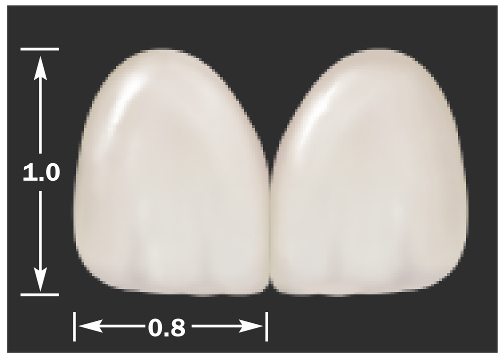
The esthetic concept of "central dominance" dictates that the maxillary central incisors must be the dominant teeth of the smile, and they must display pleasing proportions. They are the key to the smile (Figures 1 and 2).[1,2] In observing the dentition of the ideal HBM, the width of the 2 maxillary central incisors is to provide maximum functional contact with the 4 mandibular incisors when the mandible moves during incisive/surtrusion (upward) guidance (Figure 3).[3]

The length of the maxillary central incisors, in conjunction with the mandibular incisors, needs to be long enough to maintain continuous separation of the second molars during the incisive/surtrusion function. They also need to fashion an esthetic appearance with the smile and the face (approximately 12.0 mm) (Figure 4). The *approximately* 12.0 mm of length of the maxillary central incisor (must be evaluated in respect to the face) gives support to the upper and lower lip, which is an important element in developing the fullness of the lips. This length also allows a pleasing display of the incisal edges of 2 mm to 3 mm during repose position of the lips.

The incisal edges of the maxillary central incisors are convex in shape. A convex shape allows a better distribution of the loads on these surfaces and increases the efficiency of the cutting edge.

The maxillary canines (approximately 12.0 mm in length), with a more pointed form, will usually be the same length as the maxillary central incisors (Figure 5). The incisal edges of the canines touch on the same horizontal plane position as the central incisors (Figure 6).[4,5] The maxillary canines, in conjunction with the mandibular canines, also need to maintain separation during medial/surtrusion closing movements on the chewing (working) and nonchewing (balancing) sides.

The lengths of the maxillary lateral incisors, which are somewhat shorter and more rounded than that of the central incisors, allow the mandibular canines in closure to pass freely (without contact with the maxillary incisors) during the incisive/surtrusion movements (Figure 3).

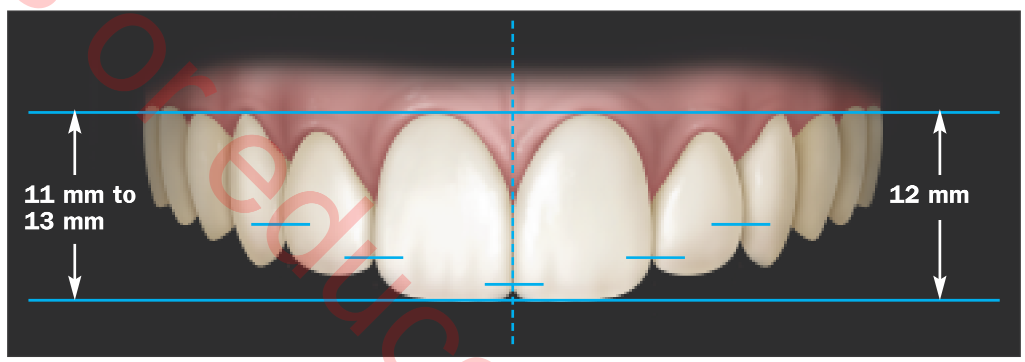


(Illustration by Dave Mazierski.)

Figure 1. The shape and location of the maxillary central incisors determines the appearance and placement of the maxillary lateral incisors and canines.

(Illustration by Dave Mazierski.)

Figure 2. The ideal incisal length for the maxillary central incisors has traditionally been influenced by the smile-line and incisal display.[1] (Reprinted with permission from the *Journal of Cosmetic Dentistry*.[2])



(Illustration by Dave Mazierski.)

Figure 3. Position of the maxillary central incisors and canines. Note that the lateral incisors are slightly shorter cervically and incisally.

MIDLINE

The term *midline* refers to the vertical contact interface between 2 maxillary or mandibular central incisors (Figure 6).[6] As found in the HBM, the midline should be perpendicular to the incisal plane and coincident with the midline of the face (Figure 6).[6] As shown in Figure 3, there must be harmony in the entire anterior complex, involving

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the gingival component, axial inclination, and the midline of the central incisors. The pupillary line, commissural line, or facial contour should never be used to establish the horizontal plane. With the patient's head perfectly erect, the maxillary canine incisal line is positioned parallel to the horizon; the midline of the central incisors is positioned perpendicular to that plane.[6]

LINGUAL SURFACES

The importance of the lingual convexities of the incisors cannot be ignored merely because they are hidden from the observer of dental esthetics. Mesial and distal convex marginal ridges of the maxillary incisors serve to strengthen the tooth against off-axis loads and allow minimal contacting surfaces of the opposing (convex) mandibular incisal edges. In his work on nature's morphology, Kataoka et al[7] states: "The mesial marginal ridge extends to the incisal edge, but the distal marginal ridge does not, and it is rather short in comparison to the mesial. This difference is the reason why the escape route of the lingual fossae is not present on the mesial aspect, but it is wide on the distal (Figures 7 and 8)."[7]

Eccentric contacts occur on the mesial marginal ridge of the central incisors during incisive/surtrusion function and guidance.[7] This movement results in the efficiency

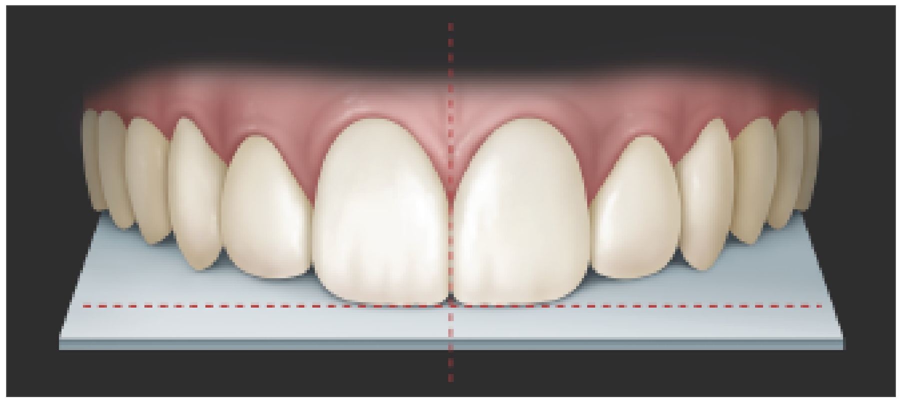
The lingual aspect of the maxillary incisors performs like a 'plate,' and the mandibular incisors function as a 'knife.'

of 2 sharp edges shearing the bolus of food between them. The lingual aspect of the maxillary incisors performs like a "plate," and the mandibular incisors function as a "knife." The prominent lingual lobe of the maxillary canine maximizes the canine medial/surtrusion guidance (continuous separation). As observed in the HBM, contacts on the lingual surfaces of the maxillary incisors stabilize the teeth in the arch and allow smooth guiding planes during the closure into the centric relation position.[8] These contacts, along with proper anterior length, permit not only continuous separation of the posterior teeth through anterior guidance but also a proprioceptive (free from interferences during function) anterior guidance.

Proprioceptors in the periodontal ligament, lips, TMJ, tongue, cheeks, muscles,

Figure 4. A 12.0-mm maxillary central incisor.

Figure 5. A 12.0-mm maxillary canine.



(Illustration by Dave Mazierski.)

Figure 6. Minor discrepancies between facial and dental midlines are acceptable and in many instances not even noticeable.[1] (Reprinted with permission from the *Journal of Cosmetic Dentistry*.[2])

and the mechanoreceptors in the pulp relay information concerning spatial relation, texture, and touch of enamel surfaces to the central nervous system. The resultant occlusomotor response lends confidence and control to the neuromuscular system, preventing pathologic wear, fracturing, and abfractures of the enamel and root structures.[9]

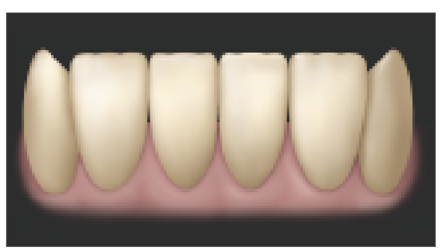
MANDIBULAR ANTERIOR TEETH FORM

Figure 9 depicts the morphology of the mandibular anterior teeth of the HBM. Note that the mandibular canines are slightly longer than the mandibular incisors. The mandibular incisors need to have length to coordinate posterior separation with the maxillary central incisors to create space between the second molars in incisive/surtrusion guidance. The lengths of the mandibular incisors are approximately 10.0 mm in length (Figure 10) and the canines approximately 12.0 mm in length (Figure 11). The greater length and vertical positioning of the mandibular canines maximizes the anterior guidance, protecting and preserving the natural, sharp, genetic tooth forms of the posterior teeth during functional movements. The importance of these vertical angulations and the length of the canines cannot be overemphasized.

The morphology of the shorter maxillary lateral incisors allows the longer mandibular canines to pass through unimpeded in an incisive/surtrusion function. Again, the form of the dentition dictates the function (Figure 12). The incisal edges of the mandibular incisors are generally 0.5 mm wide, creating sharp and efficient natural cutting tools against the convex marginal ridges of the lingual surfaces of the maxillary central incisors (Figure 13).[10,11] The mandibular lateral incisors are slightly wider than the central incisors. This additional width permits the mesial incisal edge of the lateral incisor to assist in incisive/surtrusion guidance in conjunction with the maxillary central incisors.

(Illustration by Dave Mazierski.)

Figures 7 and 8. The form of the lingual anatomy is important to provide proprioceptive contacts on convex surfaces for proper function and biomechanics. (Reprinted with permission from *Quintessence*.[7])



(Illustration by Dave Mazierski.)

Figure 9. The masticatory blade of the mandibular incisors functions as a knife, shearing the bolus of food against the mesial and distal marginal ridges of the maxillary central and lateral incisors. (Reprinted with permission from the *Journal of Cosmetic Dentistry*.[2])

INCISAL EMBRASURES

To protect the extremely hard prismatic hydroxyapatite enamel from fracturing at the sharp incisal edges, cusp points, and ridges, nature has provided convexity at the crests and corners of the maxillary and mandibular incisors.[10] The incisal embrasure space between the maxillary central incisors is approximately 1.0 mm, the space between the central and lateral incisors 2.0 mm, and the space between lateral incisors and the canines approximately 3.0 mm (Figure 3).[10,11] This embrasure space is dictated in part by the morphology of the teeth. The shorter length of the maxillary lateral incisors precludes the incisal embrasure space from being cervically higher than that of the central incisor. The distoincisal curvature of the maxillary lateral incisor creates an open and cervically placed mesial embrasure space with the maxillary canine (Figures 14 and 15). The distal contact embrasure of the canine provides a high marginal ridge contact for the exceptionally large and sharp buccal cusp of the mandibular first premolar (Figure 16). The incisal corners of the mandibular incisors are slightly rounded for protection of the enamel rods. Their embrasures are minimized, creating a wider masticatory blade.

PREMOLAR TOOTH FORM

The buccolingual angle of the buccal cusp of the maxillary first premolar is approximately 65° and the lingual cusp about 90° (Figure 17). The maxillary second premolar cusps are not quite as sharp or as long as the first premolar (Figure 18). The buccal cusp of the mandibular first premolar is exceptionally large and sharp (Figure 19).[10,11] The buccal cusp of the mandibular second premolar also is sharp, at approximately 75° (Figure 20).[10, 11]

MOLAR TOOTH FORM

Although cusp angles of molars are not as steep as those of the premolars, the cusps of the unworn molars are quite sharp (Figure 21). The reason the maxillary second and first molar has 3 roots and the mandibular molar has 2 roots is a biomechanical consideration. The loads placed on the molar teeth are greater because these teeth are closer to the fulcrum (TMJ). In the highly dense bone of the mandible, the mandibular molars have adequate support with 2 roots, but the maxillary molars with less dense bone require 3 or more roots. The mesiodistal cusp angles of the maxillary molars average approximately 100°, and the buccolingual cusp angles average about 90°. The triangular ridge height to groove depth often exceeds 90°. Unworn molar cusp heights to fossa depths range from 3.0 mm to 4 mm.[10,11] The height of the molar cusps diminishes the more distally they are located, in order to improve the crown-to-root ratio under load. This favorable crown-to-root ratio and the sharpness of the posterior molar morphology reduces masticatory loads on the hard and soft tissues.

ANTERIOR GUIDANCE

The vertical and horizontal relationship of the coupled maxillary and mandibular incisors is critical to the incisive/surtrusion component of the anterior guidance. The relationship of 2 mm to 3 mm of horizontal overlap and 3 mm to 5 mm of vertical overlap allows adequate separation of the posterior teeth during the incisive/surtrusion movement; this vertical/horizontal relationship also allows space for speech and rest positions.

Figure 10. A 10.0 mm average length mandibular incisor.

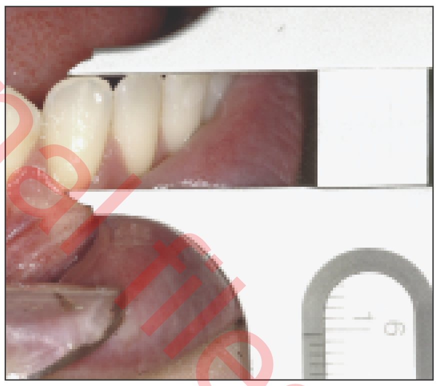
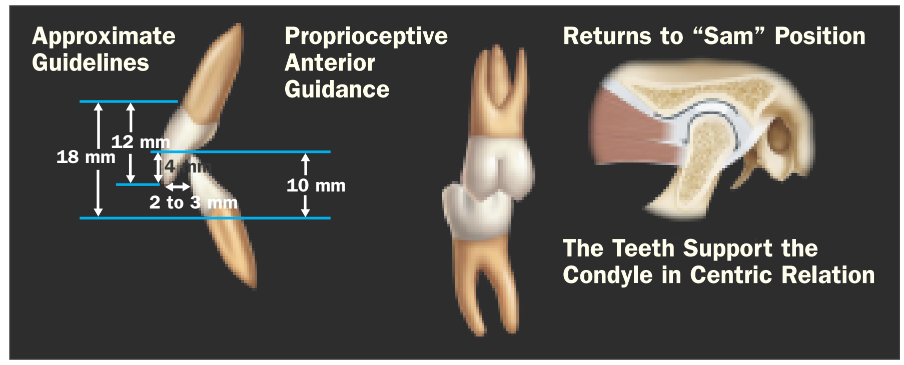


Figure 11. A 12.0 mm mandibular canine.

A line connecting the incisal edges of the maxillary canines should be parallel to the horizon and the midline of the central incisors perpendicular to that plane. This relationship is critical from a functional aspect.[6] The midline and horizontal plane relationship sets the stage for incisive/surtrusion and canine medial/surtrusion guidance (Figures 22 and 23).

Two critical elements of tooth position prevent overloading the maxillary and mandibular incisors. First, the incisors are located at the end of a Class III lever with the TMJ as the fulcrum point, and the elevator muscles apply load between the incisors and the joint. Secondly, when the mandible moves forward to perform the incisive/surtrusion function, the edge-to-edge contact of the maxillary central incisors is on the 4 mandibular incisors (Figure 22). This position allows these 6 anterior incisors to share the load of incision. If the maxillary occlusal plane is not parallel to the horizon in conjunction with the mandible, an even contact with the mandibular incisors is not possible. This condition creates eccentric contacts and can result in abfractive lesions (Figures 24 and 25).[6]

The same principle applies to the canine chewing medial/surtrusion guidance. When the mandible moves medially towards closure, the canines



(Illustration by Dave Mazierski.)

Figure 12. When the condyles are in centric relation, all teeth occlude evenly in the intercuspal position. When occlusal contacts are uneven, posterior occlusal interferences in incisive/surtrusion and right and left medial/surtrusion border jaw movements avoidance patterns will develop.

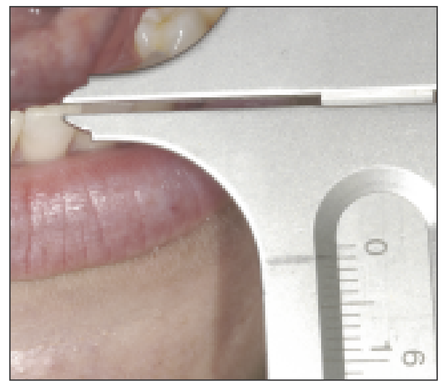
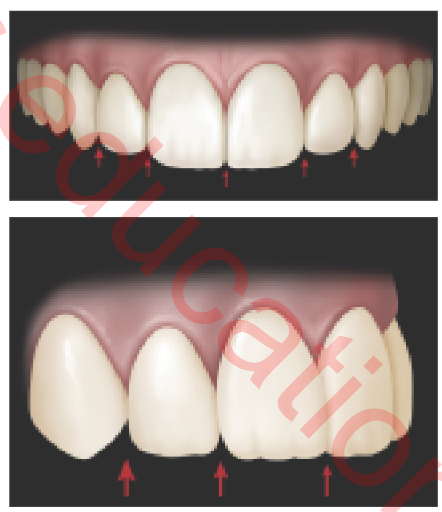
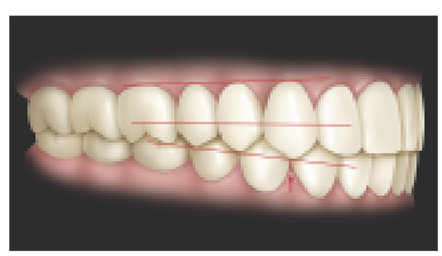


Figure 13. Masticatory blade of the mandibular incisor is approximately 0.5 mm.



(Illustration by Dave Mazierski.)

Figures 14 and 15. The labial anatomy should mimic the morphology of the natural dentition. Note the presence of the lobes on the labial surface. (Reprinted with permission from the *Journal of Cosmetic Dentistry*.[2])



(Illustration by Dave Mazierski.)

Figure 16. The functional relation of the maxillary canines with the mandibular canines and first premolars eliminates the possibility of applying horizontal vectors to maxillary and mandibular incisors, premolars, or molars during eccentric movements of the mandible.[12] (Reprinted with permission from the *Journal of Cosmetic Dentistry*.[2])

will approach and pass the edge-to-edge position, leaving the posterior teeth separated until final closure (Figure 23). If the maxillary and mandibular occlusal planes are not parallel, the posterior teeth may come into contact before final closure (occlusal interferences) on the chewing and nonchewing sides.

The midlines of the maxillary and mandibular anterior teeth should also be congruent, ie, coinciding at all points when superimposed. Any deviation of the mandibular midline mesial or distal to the maxillary midline creates an increase in the horizontal overlap of one of the maxillary canines, resulting in diminished canine guidance on that side and subsequent posterior interferences in function or flat cusp forms on the nonchewing (balancing) side.

AXIAL INCLINATION

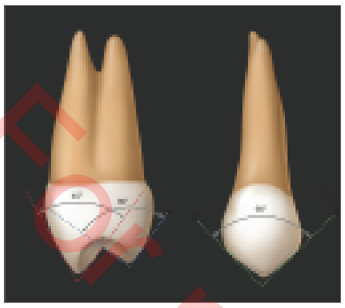
When analyzing the axial inclination from the perspective of the HBM, we must evaluate the dentition in 3 planes of space: vertical, horizontal, and sagittal. These 3 planes must be evaluated with respect to the anterior and the posterior teeth. These angulations promote healthy mastication without inflicting wear on the dentition. The axial inclination compares the long axis alignment of the maxillary anterior teeth, as viewed at the smile-line, to the vertical midline of the central incisors. From the maxillary central incisor to the canine, there should be a natural progressive increase in the mesial inclination of each subsequent anterior tooth (Figure 26).[10,12]

In the frontal plane, the maxillary lateral incisors and canines are angled toward the midline in a mesial cant. This angulation allows compensation for the arch width difference between the maxillary and the mandibular teeth, permitting the correct anterior coupling of the incisors and the placement of the maxillary canine distal to the mandibular canine (Class I relationship). The canted position also allows the central incisors to be positioned on all 4 mandibular incisors in incisive/surtrusion functions (Figure 26). The mesial cant of the canine positions the maxillary canine forward to engage the mandibular canine on the crest of the distal labial lobe to assist and maximize canine medial/surtrusion guidance. Canine medial/surtrusion guidance provides a continued separation of the posterior teeth in lateral closing movements of mastication. Only in the maximum intercuspation do the posterior teeth finally come into contact. Gibbs and Lundeen[13] have indicated the teeth touch only during swallowing, not during chewing. Adequate incisive guidance should create at least 2.0 mm to 3.0 mm of clearance or separation between the maxillary and the mandibular second molars when the maxillary and mandibular incisors are in an end-to-end position (Figure 22).

...we must evaluate the dentition in 3 planes of space: vertical, horizontal, and sagittal.

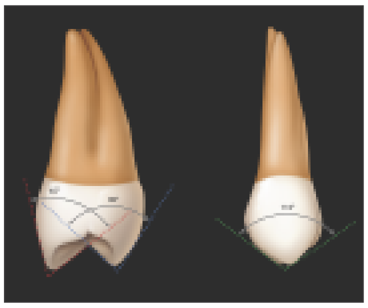
Proper canine medial/surtrusion guidance should result in 1.0 mm to 2.0 mm of clearance (separation) of the maxillary and mandibular second molars on the chewing (working) side, and 2.0 mm to 3.0 mm of clearance (separation) of the same molars on the nonchewing (balancing) side (Figure 23). There are 2 reasons for the necessity of this clearance. First, separation allows efficient sharp cusp forms without interference in function. The second reason for this separation is the avoidance of contact of the teeth during physiologic flexure of the mandible under masticatory loads.

In the sagittal plane, the anterior dentition should cant labially at approximately 98° to 113° for the maxillary incisors and 85° to 104° for the mandibular incisors.[14,15] This labial cant allows the optimal anterior coupling of the maxillary and mandibular teeth in maximum intercuspation and direction of compressive forces of the opposing incisors along the long axis of their roots during incisive/surtrusion actions where this type of force is better tolerated by the osseous structures (Figure 12).[10,16] The very nature of shear forces on the maxillary central incisors during incisive/surtrusion movements demands the greater cross-sectional area of their roots and



(Illustration by Dave Mazierski.)

Figure 17. The buccal cusp of the maxillary first premolar is 65°, which acts as a second line of defense if the canines wear to protect the back teeth from eccentric contacts.

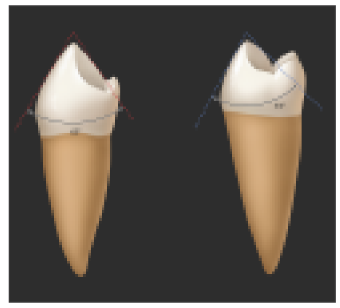


(Illustration by Dave Mazierski.)

Figure 18. The buccal cusp of the maxillary second premolar is about as sharp as the first premolar but more obtuse buccolingually.

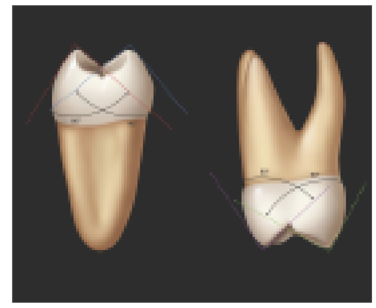
(Illustration by Dave Mazierski.)

Figure 19. The buccal cusp of the mandibular first premolar is 65° buccolingually and 90° mesiodistally.



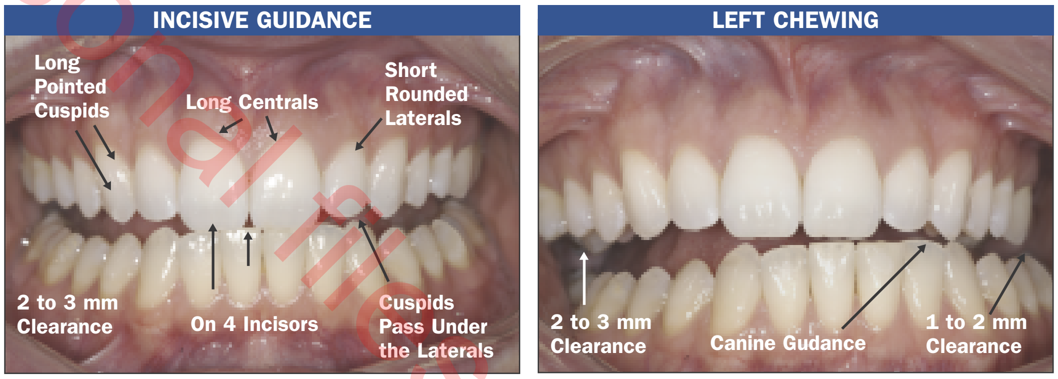
(Illustration by Dave Mazierski.)

Figure 20. The buccolingual angle of the mandibular first premolar is 10° steeper than the second premolar.

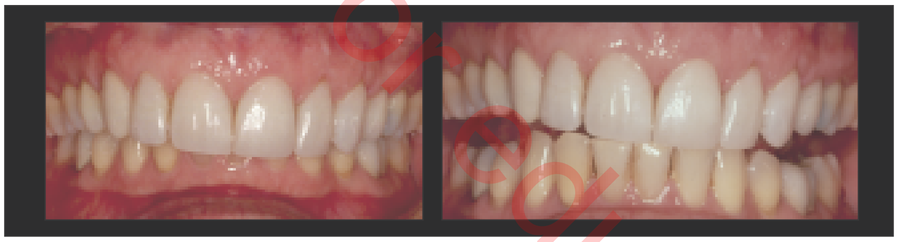


(Illustration by Dave Mazierski.)

Figure 21. The maxillary first molar has 3 roots, and the first mandibular molar has 2 roots.



Figures 22 and 23. Ideal morphology of the maxillary and mandibular natural anterior dentition.



Figures 24 and 25. The occlusal plane cants to patient's right-to-left, creating eccentric guidance on left maxillary lateral incisor instead of the 2 maxillary central incisors.

there with the wider emergence profile of the crown of these incisors (Figure 27).[16]

Studying nature, several clinicians have noted the presence of cusps on the posterior adult teeth.[17-20] In the frontal and sagittal plane, the angulations of the cusp tips of the teeth rise progressively in a posterior direction (curve of Spee) (Figure 16). The crown-to-root ratio diminishes as we proceed posteriorly from the first premolar to the second molar. The second molar is closer to the fulcrum (the TMJ); consequently, the loads are greatest on the second molar (Figure 27).[21] This smaller crown-to-root ratio provides the design of the second molar the ability to withstand increased loads. The maxillary second molar is a guiding tooth. The second molar sets higher on the plane of occlusion and has a greater curve of Spee than the first molar. The curve of Wilson is relatively horizontal, which prevents the mesial lingual cusp of the second molar from being set too low on the occlusal plane. The mesial-lingual cusp of the maxillary second molar is the most frequently interfering cusp. Unfortunately, this molar is rarely banded and correctly positioned during orthodontic treatment.[22]

In the frontal plane, the axial angulations of the buccal surfaces of the mandibular posterior teeth cant toward the lingual aspect (curve of Wilson). This buccolingual cant promotes posterior guidance during closure. When there is a bolus of food on the chewing side preventing tooth contact, the guidance to closure takes place on the nonchewing side from the second molar forward, ie, first molar, second premolar, first premolar, and the canine (Figure 16).[11,23]

In the sagittal plane, the lengths of the buccal cusps of the maxillary canine, first premolar, second premolar, and first molar are approximately 5.0 mm, 4.0 mm, and 3.0 mm, respectively, when measured coronally from the interproximal contact points. Again, this sequencing of the teeth establishes posterior guidance and enhances crown-to-root ratio. The mesial and distal embrasures of the canine usually are at approximately 90°. Moving in a posterior direction, lines connecting the maxillary cusp tips and the gingival marginal crests converge. The 90° embrasures and the gingivally placed marginal ridges allow space for more natural (sharper) cusp forms of the mandibular posterior teeth—developmentally, and restoratively (Figure 28).[11]

MANDIBULAR MOVEMENT

The primary function of our teeth is to incise or crush the bolus of food. We have previously discussed the form of the teeth and the importance of each tooth position or placement within the 3 planes of space in accomplishing this function. Also mentioned is the importance of the condylar head seated in the fossa when crushing the bolus of food.[24]

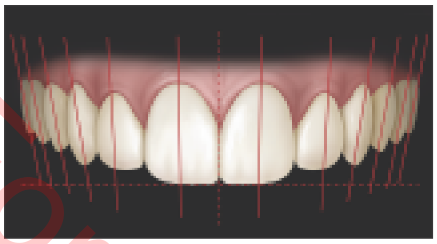
The primary function of our teeth is to incise or crush the bolus of food.

Even though the condylar angle does not influence the morphology of the posterior teeth, it is important for the restorative dentist to understand the effect the condylar angle has on the closing path of the teeth in creating potential interferences of the mesial and distal cusps of the second and first molars in incisive/surtrusion guidance. The shallower the condylar angle, the steeper the incisal overlap will have to be to prevent incisive/surtrusion interferences of the posterior teeth.

The Bennett path on the curved nonchewing side affects the approach of the cusps of the molar teeth. Likewise, the Bennett shift (loose joints) can create eccentric contacts with medial/surtrusion guidance on the buccal and lingual cusps of the second and first molars. Some clinicians believe the disc, which is down and forward at this point, is at greater risk of displacement.[10] This disc position is why it is of such critical importance to have the horizontal and vertical overlap of the canines positioned in such manner that there are no interferences on the nonchewing side on closure, specifically the mesial lingual cusp of the maxillary second molar.

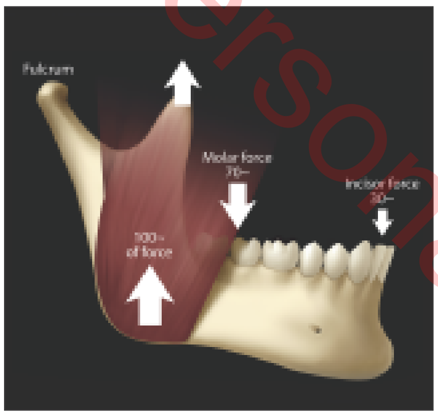
The steepness of the occlusal plane is also an important factor in potentially creating eccentric interferences in the posterior dentition. The steeper the setting of the occlusal plane superior to the Frankfort plane, the more likely it is that posterior interferences will occur because of the proximity of the molars to the condylar pathway.

When the mandibular canine cusp tip moves closer to the to cusp tip of the maxillary canine, on the chewing side, proprioceptive guidance transfers from the canines to the mesial-lingual cusp of the maxillary second molar on the nonchewing side. The next guiding tooth is the first molar. The distalbuccal cusp of the maxillary first molar sets lower on the occlusal table, guiding the teeth into the proper position to initiate chewing. Next, the buccal cusps of the mandibular second and first premolars begin to aid in the path of final closure. Finally, continuing on the nonchewing side, the canine guides us in the last millimeter of final clo-



(Illustration by Dave Mazierski.)

Figure 26. Axial inclination can also refer to the degree of tipping in any plane of reference.[1] (Reprinted with permission from the *Journal of Cosmetic Dentistry.*[2])



(Illustration by Dave Mazierski.)

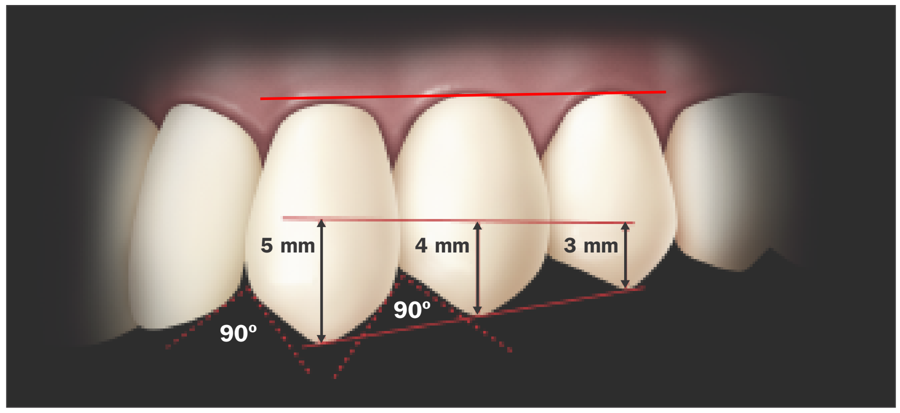
Figure 27. Anterior teeth have a mechanical protective advantage over the posterior teeth because they are further away from the fulcrum.

sure. D'Amico states[14,15]: "We have the interlocking relation of the maxillary canine between the mandibular canine and first premolar tooth. This is the most important articulation of the natural teeth, since it guides the mandible and the mandibular teeth into functional centric occlusion and serves to prevent the development of any horizontal (force) vectors on the incisors, premolars, and molars."[14,15]

CONCLUSION

Every attribute of nature's ideal tooth and joint form is involved in a chewing system that prevents overload forces and maximizes esthetics. Understanding how to restoratively duplicate nature's occlusal scheme facilitates the guidance of the posterior teeth with the condyles in centric relationship. These observations, obtained from studying the healthiest and finest of natural dentitions, are known as the principles of the HBM.[10,25-29] When clinicians understand the form, they will achieve optimal function in dental treatment. When that function is achieved, restoratively or orthodontically, the esthetics will follow. Before the clinician can restore the form, however, the TMJ must be in an orthopedically stable position,[8] which is optimal for a final diagnosis and the creation of a stable occlusion.

Part 3 in this series will discuss how that position can be achieved.✦



(Illustration by Dave Mazierski.)

Figure 28. These gingivally placed marginal ridges create generous and beautiful natural buccal cusp forms, which are also functionally and esthetically compatible with good anterior lengths and positions of the incisors.

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