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DETERMINANTS OF OCCLUSION IN FIXED PARTIAL DENTURE

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Abstract

Occlusal determinants are the factors that affect how the upper and lower teeth align, supporting proper jaw function and positioning. These factors include tooth contact, the temporomandibular joint (TMJ), and the neuromuscular system, all of which are essential for efficient chewing and preventing dental problems. Understanding these determinants is crucial for diagnosing occlusal disorders and developing effective treatment planning

KEYWORDS: *Occlusal Determinants, Incisal Guidance, Centric Relation, Envelope of Function*

INTRODUCTION

Like all human systems, the tissues and functions of the masticatory system undergo adaptation, wear, stress, aging, and may be affected by disease. As a result, occlusion is not static; it changes over time, with responses ranging from healthy adaptation to complete dysfunction. [1]

The stomatognathic system is so finely designed that even a minor alteration—such as a micron change in the occlusal surface of a small restoration—can be detected by some patients and may cause discomfort. At the same time, it possesses a remarkable ability to adapt, even in cases where a complete denture is used in a fully edentulous situation. When patients seek replacement for missing teeth, it is important to recognize that their stomatognathic system may have been functioning harmoniously, often without symptoms, even in the presence of minor issues such as spacing or a single-tooth crossbite, unless there are conditions like temporomandibular dysfunction or bruxism. [2]

According to Beyren, features of occlusion are

1. highest number of bilateral centric stops during closure in maximum intercuspation, regardless of any particular relationship.
2. Whenever possible, axial loading of posterior teeth for optimal force distribution within the alveolus.
3. Freedom in the retrusive range of occlusal contact movement, ensuring that the mandible is not forced into a border position when the teeth come together in centric occlusion.
4. Multidimensional freedom of occlusal contact movement, allowing for group function during laterotrusion and anterior guidance during protrusion. This setup promotes the most favorable force distribution for various functional movements.
5. Proper vertical dimension of occlusion. [3]

Dawson (1974) also proposed his concepts for achieving an ideal occlusion:

1. Stable contacts on all teeth when the condyles are in the most superior posterior position.
2. Anterior guidance that aligns with the border movements of the envelope of function.
3. Disclusion of all posterior teeth during protrusive movements.
4. Disclusion of all posterior teeth on the balancing side.

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5. Absence of interference from posterior teeth on the working side with either the lateral anterior guidance or the condylar border movements. [4]

In normal occlusion, the neuromuscular system functions reflexively, generating mandibular movements that prevent premature contacts. This helps guide the mandible into a position of maximum intercuspation, even though the condyle may not be in the optimal position. The outcome may include slight hypertonicity in surrounding muscles or stress on the TMJ, but it typically remains within most people's physiological capacity to adapt and does not cause discomfort.[1]

PRIMARY REQUIREMENTS FOR OCCLUSAL THERAPY

1. TMJs that are stable and comfortable: the TMJs are where all occlusal analyses begin. It must be painless for the jaw joints to operate and withstand loading stresses. Any dental procedure that works with the teeth's occlusal surfaces always begins with this.
2. Anterior teeth that are in harmony with the envelope of function and in appropriate alignment with the occlusal plane, lips, and tongue.
3. Non-interfering posterior teeth: Neither the anterior guidance in the front nor the comfortable TMJs in the back should be hampered by posterior occlusal contacts.[5]

DETERMINANTS OF OCCLUSION

The two condyles and the contacting teeth resemble the three legs of an inverted tripod, suspended from the cranium. This tripod's movement is influenced by three key factors: the right and left temporomandibular joints (TMJs) at the rear, the teeth of the maxillary and mandibular arches at the front, and the neuromuscular system overall. Dentists cannot alter the TMJs, which act as the unchangeable posterior determinants of mandibular movement. However, these joints influence how the mandible and teeth move by defining the pathways along which the condyles travel during muscle-driven jaw movements. The measurement and replication of these condylar movements form the foundation for using articulators.[6]

The anterior determinant, the teeth, guides the mandible in multiple ways. The posterior teeth provide vertical stops for mandibular closure and direct the mandible into maximal intercuspation, a position that may or may not align with the ideal position of the condyles in the glenoid fossae. The anterior teeth (from canine to canine) assist in guiding the mandible during right and left lateral movements, as well as in forward (protrusive) movements.

The anterior teeth are particularly well-suited for guidance due to several factors:

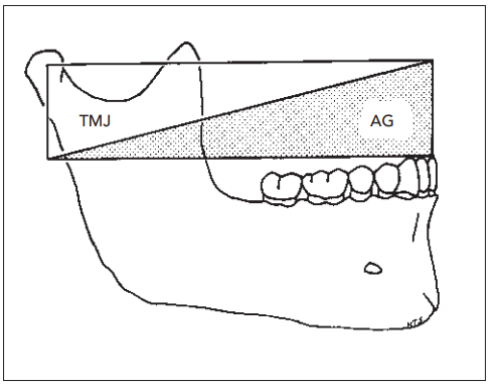
- Canines possess the longest and strongest roots in each arch.
- The load decreases with distance from the fulcrum (Class III lever).
- Proprioceptive feedback and reflexes help reduce the applied load.[6]

i. POSTERIOR DETERMINANTS

The temporomandibular joint (TMJ) plays a key role in mandibular movements, with its influence expressed through the inclination of the articular eminence (condylar inclination), the shape of the medial wall of the glenoid fossa, and the configuration of the condyle. These three factors govern the direction, duration, and timing of mandibular movements, thereby impacting occlusal morphology, such as the steepness of cuspal angles and the orientation of ridges and grooves. For example, the shape and angle of the articular eminence influence mandibular movement and tooth positioning by determining the path the condyles follow during jaw motion. The angulation of the articular eminence typically ranges from 17 to 77 degrees at the midpoint inclined plane. The posterior determinants can be further categorized into vertical factors, which affect the steepness of cuspal angles, and horizontal factors, which influence the direction of occlusal ridges and grooves. [7]

ii. ANTERIOR DETERMINANTS

The anterior determinant refers to the factors within the dentition that affect both occlusal morphology and mandibular movements. While the posterior teeth provide a vertical stop for the mandible, the anterior teeth play a crucial role in guiding the mandible into the maximum intercuspation position (MIP), as well as during right and left excursions and protrusive movements. However, in patients with an anterior open bite, the influence of the anterior teeth is diminished, and the posterior teeth may take over the guidance of the mandible during lateral excursions and protrusive movements. It is important to recognize that the anterior determinant encompasses the role of both anterior and posterior teeth in shaping mandibular movements, not just the anterior teeth.[7]



The farther forward a tooth is located, the less it is influenced by the TMJ and the more it is guided by anterior guidance (AG). [8]

Elements of the anterior determinant include:

1. **Incisal guidance:**

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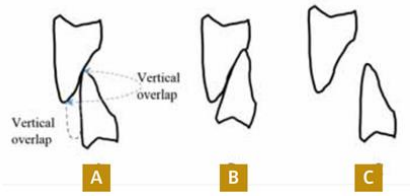
Incisal guidance refers to the impact of the contacting surfaces of the maxillary and mandibular anterior teeth on mandibular movements. The degree of steepness of this guidance is determined by the horizontal and vertical overlap of the anterior teeth. In normal occlusion, the lingual surfaces of the six upper anterior teeth can be regarded as the incisal guide factor. The muscles of mastication and the temporomandibular joints regulate the movements of the mandible when the teeth are not in functional contact.[9]



INCISAL GUIDANCE [10]

1. **Occlusal plane:**

The occlusal plane is defined as the average plane formed by the incisal and occlusal surfaces of the teeth. It is an imaginary plane that aligns with the incisal edges of the anterior teeth and the cusp tips of the posterior teeth. The cusp angles of the posterior teeth are influenced by the relationship between the occlusal plane and the condylar guidance. Therefore, when the occlusal plane is parallel or nearly parallel to the condylar guidance, the cusp height must be relatively short, and the opposite is true when the angles differ.

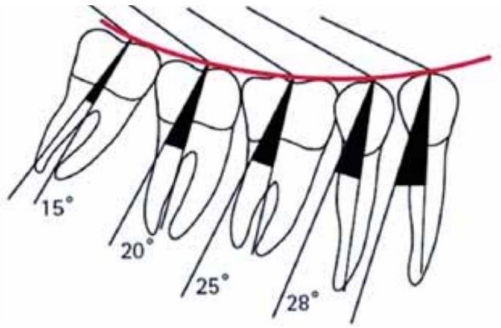
2. **Curve of Spee :**

The antero-posterior curve, also known as the Curve of Spee, touches the tips of the canine teeth and the functional cusps of the mandibular posterior teeth. It extends distally through the ramus and passes through the condyle. The design and positioning of this curve serve two key functions:

CURVE OF SPEE [7]

b. The long axis of each mandibular posterior tooth is aligned parallel to the arc of closure, allowing maximum resistance to occlusal forces. This alignment ensures that most of the periodontal ligaments contribute to the dissipation of the occlusal forces.

c. Posterior disclusion is more easily achieved when the mandibular occlusal plane is either flat or convex. Even with a flat incisal guidance, the forward movement of the condyle on the articular eminence occurs at a steeper angle compared to the posterior part of the occlusal plane, facilitating posterior disclusion.



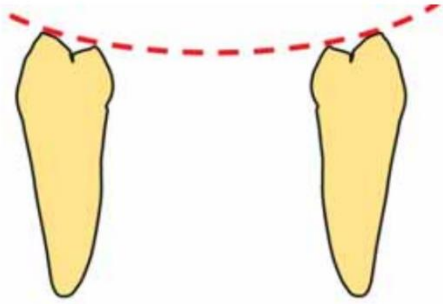
The long axis of each mandibular posterior tooth is aligned parallel to the arc of closure, allowing it to provide maximum resistance to occlusal forces. [7]

1. **Curve of Wilson:**

The Curve of Wilson is the bucco-lingual (mediolateral) curve that contacts the buccal and lingual cusp tips on each side of the dental arch. It arises from the inward inclination of the mandibular posterior teeth and the outward inclination of the maxillary posterior teeth. The Curve of Wilson serves two important functions for the masticatory system:

a. It provides optimal resistance to masticatory forces by aligning the teeth parallel to the direction of the medial pterygoid muscles, which are key elevator muscles of the mandible.

b. The positioning of the lingual cusps of the mandibular teeth allows the tongue to direct food toward the occlusal table, while the elevated buccal cusps prevent food from passing beyond it. Similarly, the lower position of the maxillary palatal cusps ensures that food remains on the occlusal table.[7]



CURVE OF WILSON[7]

FORMULA FOR A PERFECT OCCLUSION

When the condyle-disk assemblies are fully placed in their respective sockets, the initial step is to establish synchronous, equal-intensity contacts on every tooth. The posterior teeth's cusp tips—shown by dots—are in contact. As the jaw moves laterally and forward, the lines on the anterior teeth show constant contact between the incisal margins and the centric relation. This formula shows that all posterior teeth become disoriented as soon as the jaw departs from the centric relation

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and that contact occurs in the centric relation. Together with the condylar path, the anterior teeth (the anterior guidance) are in charge of keeping the back teeth apart during all excursions.

The causes of this posterior separation are due to the fact that nearly all of the elevator muscles contract at this time, significantly lowering the stresses acting on the anterior teeth and TMJs.[6]

- **CENTRIC RELATION** : Centric jaw relation is the most retruded position of the mandible to the maxillae at an established vertical dimension which is repeatable and recordable.[11]
- **CENTRIC OCCLUSION** refers to the functional relationship between the teeth, while centric relation is a maxillomandibular orientation that typically helps define the horizontal aspect of a planned centric occlusion.[12]
- **MAXIMUM INTERCUSPATION**: Maximum intercuspal position (MIP) is defined as the complete intercuspation of the opposing teeth, independent of the condylar position in the glenoid fossa. It is also known as the best fit of the teeth, regardless of the condylar position. MIP is a tooth-determined position where the mandible is held in its most cranial position, stopped definitively by tooth contact. In this position, the condyle-disc assembly is typically anterior and inferior, and may also be medial or lateral, or a combination of these, in comparison to its position in centric relation (CR). The average distance between CR and MIP in 90% of the population is 0.5–2 mm. In MIP, maximum occlusal force can be applied, and the greatest number of occlusal contacts is achieved, making it the position of maximum mandibular stability. MIP provides a stable position for the mandible during activities such as swallowing and intense physical exertion. In individuals with normal physiological occlusion, MIP is a precise, easily identifiable position when an adequate number of posterior teeth is present. It is the most commonly used reference position in clinical practice.[13]
- **ANTERIOR GUIDANCE**

1. The effect of the contacting surfaces of the anterior teeth, which restrict mandibular movements.
2. The influence of the contacting surfaces of the guide pin and anterior guide table on articulator movements.
3. The creation of a relationship between the anterior teeth that prevents posterior tooth contact during all eccentric mandibular movements. This includes anterior protected articulation, group function, and mutually protected articulation[2]

The closer a tooth is to a movement determinant, the more it is influenced by that determinant. Teeth in the anterior region are primarily guided by anterior guidance and are less influenced by the TMJ, while posterior teeth are influenced both by the TMJs and by anterior guidance.

The four main determinants of anterior guidance are:

1. Esthetics
2. Phonetics
3. Condylar Border Movements
4. Positional Relationships of the Maxillary and Mandibular Anterior Teeth

I. Esthetics and Phonetics: These are best determined by the methods proposed by Pound.

II. Condylar Border Movements: In the absence of teeth, the movement pattern of the mandible is determined by the muscles, ligaments, and the functional form of the temporomandibular joints (TMJ). For optimal function, the occluding surfaces of the teeth must be in harmony with these movements to avoid damage to the masticatory system. Each individual has unique condylar border movements, which occur within the envelope of motion as described by Posseh. These movements are influenced by the anterior teeth and the neuromuscular system.

During masticatory function, the condyles move from one side to the other along various border pathways as the teeth pass through centric occlusion. The extent to which these lateral border pathways are used depends on the type of food being chewed. Granger demonstrated that more border pathways are engaged when chewing meat compared to cheese. These border movements occur against the condyle-disc assemblies and the eminence, allowing for greater power during chewing. Since more power is needed to chew meat, more border pathways are utilized. If tooth interferences prevent the condyles from reaching these border pathways, muscle dysfunction can occur. Anterior teeth can also contribute to such interferences.[14]

- **CENTRIC SLIDE** : Centric slide is defined as a movement of the mandible while in centric relation, from the initial occlusal contact into maximum intercuspation (The Glossary of Prosthodontic Terms, 2005)
- **CONDYLAR GUIDANCE** : Mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence(GPT-9)

ENVELOPE OF FUNCTION

A. ENVELOPE OF MOTION

A three-dimensional envelope of motion that depicts the mandible's maximum range of motion can be created by combining mandibular border movements in the sagittal, horizontal, and frontal planes. Despite the envelope's distinctive shape, individual variations will be observed. While ligaments and joint architecture that limit or restrict movement mostly dictate the other borders, tooth interactions determine the superior surface of the envelope.

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The tautness of the deep capsular ligaments determines the mandibular envelope of movement restrictions (Posselt 1952). But before the mechanical restriction of the ligament is reached, muscular mechanisms take over. Every condyle has a free, but constrained, range of motion along its canial joint surface. This could be referred to as the condylar point's contact movement surface. [15,16]

B. ENVELOPE OF FUNCTION

Within these same limitations of border movements in all three planes, the mandible moves naturally during normal function. These have occasionally been referred to as "free" motions inside the envelope of motion, or the "Envelope of Function." The shape, position, and contour of the maxillary anterior teeth—particularly the incisal edge position and the lingual contours—determine the constraints of these freely moving teeth. The lips support the tooth's location or facial contour, and the tooth stays in this position by nature. Whether the envelope of function is steep or shallow depends on the lingual contours and incisal edge. The constraints of the border motions (Envelope of motion) are the same independent of the position of the maxillary central incisor. What does alter, though, is the "free" movement or "Envelope of function." [17]

1. INFLUENCE OF TEETH

The movement of the mandible's back end is determined by the condylar route. That is the initial factor that determines occlusion. Teeth regulate the second determinant. The anterior guidance, which controls the movement of the mandible's front end, should ideally be that. The mandible's functional course in a perfected occlusion is determined by the combination of anterior and condylar guidance. All posterior tooth contact in an ideal occlusal relationship is dictated by the combined border routes at the mandible's front and rear ends. Consequently, the mandible's functional route is mostly established by the anterior teeth. This indicates that the anterior guidance is established by the location, inclination, and lingual contour of the upper anterior teeth. In order to ascertain whether anterior guidance is in harmony with or interferes with an ideal envelope of function, it is also crucial to consider the position of the upper incisal margins. The second most crucial choice a dentist must make about occlusion is to determine exactly the right incisal edges.[5]

ORGANIZATION OF OCCLUSION:

Three main concepts describe how teeth should or should not contact during various functional and excursive movements of the mandible: (1) bilateral balanced occlusion, (2) unilateral balanced occlusion, and (3) mutually protected occlusion.[6]

I. BILATERAL BALANCED OCCLUSION

Bilateral balanced occlusion, originally based on the work of von Spee and Monson, is a concept that is less commonly used today than it was in the past. This approach is particularly valuable in complete denture construction, where contact on the nonworking side helps prevent denture tipping. Later, this concept was extended to natural teeth during full occlusal rehabilitation, aiming to reduce the load on individual teeth by distributing stress across as many teeth as possible. However, it soon became evident that achieving this arrangement was challenging. The multiple tooth contacts that occurred during mandibular excursions led to excessive frictional wear on the teeth. [6,17]

II. UNILATERAL BALANCED OCCLUSION

Unilateral balanced occlusion, also known as group function, is a widely accepted approach in restorative dentistry today. This concept originated from the work of Schuyler and others, who observed that tooth contact on the nonworking side could be destructive. They concluded that since cross-arch balance wasn't necessary in natural teeth, it would be preferable to eliminate all nonworking side contacts.

In unilateral balanced occlusion, all teeth on the working side make contact during a lateral movement, while the nonworking side teeth are shaped to remain free of contact. This group function on the working side helps to distribute the occlusal load effectively. This approach also protects the centric holding cusps (the mandibular facial cusps and maxillary palatal cusps) from excessive wear, helping to preserve the occlusion. The functionally generated path technique, first described by Meyer, is used to create restorations in unilateral balanced occlusion and has been adapted by Mann and Pankey for complete-mouth occlusal reconstruction.[8,17,18]

III. MUTUALLY PROTECTED OCCLUSION

Mutually protected occlusion, also referred to as canine-protected occlusion or organic occlusion, was developed based on the work of D'Amico, Stuart, Stallard, Stuart, Lucia, and members of the Gnathological Society. They observed that in individuals with a healthy periodontium and minimal wear, the anterior teeth overlapped in such a way that prevented the posterior teeth from contacting on either the working or nonworking side during mandibular movements. This separation, known as disocclusion, ensured that only the anterior teeth carried the load in excursive movements, minimizing frictional wear on the posterior teeth.

In this concept, maximal intercuspation aligns with the mandible's optimal condylar position, where all posterior teeth make contact and forces are directed along their long axes. The anterior teeth either contact lightly or have a slight separation (about 25 microns), protecting them from obliquely directed forces. This arrangement, where anterior teeth protect the posterior teeth during mandibular excursions and posterior teeth protect anterior teeth in intercuspal position, is known as mutually protected occlusion. This occlusal setup is widely accepted due to its ease of fabrication and high patient tolerance.[6]

CONCLUSION

The masticatory system is a dynamic, adaptable structure influenced by aging, stress, and pathology, with occlusion evolving over time. Despite its sensitivity to even minute changes, the system demonstrates remarkable resilience and

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compensatory capabilities. Mandibular movement is governed by an intricate relationship between the temporomandibular joints, teeth, and neuromuscular system, forming a three-legged "tripod" of control. Functional movement occurs within defined spatial boundaries—the envelope of motion and the more variable envelope of function—both shaped by anatomical and occlusal factors. Understanding these components, along with the principles of occlusal organization, is essential for effective dental care and restoration planning.

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