Dr. P.A. TIPTON
B.D.S., M.Sc., D.G.D.P., UK.

1. HOFFMAN & REUGENOS
   -Section 1- Part A. Introduction to the study of occlusion.
   pp: 1- 29

Purpose of study:

Method:

Results:

Discussion:

Conclusions:

Comments:
INTRODUCTION

Occlusion is the key to oral function and subsequently the key to restorative oral diagnosis. In spite of this, occlusion is one area that is frequently overlooked or neglected in many dental offices. This tendency to take for granted the patient’s occlusion is quite understandable since no dental subject has had a more controversial history, with more divergent opinions and conflicting theories than has dental occlusion. Consequently, there has been a critical lack of adequate undergraduate education in the field of occlusion.

Analysis and clarification of the existing conflict in this field appears to be a most worthwhile project. The opinions, theories, and discrepancies must be resolved. Prerequisites and criteria must then be established in order to have a basis for teaching occlusion to dental students and to re-educate practicing dentists. Better visual aids, methods, and technics are needed to accomplish this educational problem.

A post-graduate course has been established at The Ohio State University, College of Dentistry, to study current concepts of occlusion. This manual is a compilation of the material used in this postgraduate program. At this stage of dental history occlusion is but an "infant" and infants grow fast and develop rapidly. It is our hope that occlusion will follow this same pattern and that this manual will serve as a valuable adjunct for teaching purposes during this period. As new information is made available through dental research and clinical studies modifications will be necessary and supplemental material will be added.

In 1924, Shaw, an anthropologist, stated: "The writing cut with such precision upon the complex patterns of teeth may indeed be hieroglyphics, but, even so, it was surely no random and meaningless scribbling. More probably it was a real organic language in which the principals of tooth design and mechanics were inscribed, and we might yet succeed in deciphering it if first we took pains to learn its dynamic alphabet and master the elements". In essence, this means that once we decipher the hieroglyphics on the occlusal surfaces of the teeth we will have mastered occlusion. These so called hieroglyphics are the
ridges and grooves, their placement and direction, the cusp height and fossa depth and their locations, and the interrelationship of the lower anterior teeth with the lingual concavity of the maxillary anterior teeth.

Years of research-and study-have-led-to-one current-concept--of occlusion based on accurate data which meets the strict requirements of the scientific method. Utilizing a recording device which accurately plots the border movements of mandibular function; and transferring this data to an instrument which is capable of faithfully reproducing it; it is now possible to study, outside the mouth, the interaction of the occlusal surfaces of the teeth with the temporomandibular joint. The information thus gained is the physiological key to diagnosis and this knowledge, when properly applied results in greater benefit to the patient. Such a diagnostic study may be termed a "functional occlusal analysis". The data accumulated from such studies has led to the gnathological concept of occlusion. Also, gnathological research has finally deciphered the hieroglyphics on the occlusal surfaces of the teeth, referred to by Shaw. It now becomes our purpose as dentists and dental educators to put this knowledge to work for us. The various factors influencing these, so called, hieroglyphics have been labeled "The Determinants of Occlusal Morphology" and will be discussed in detail later in the manual.

Our next concern would seem to be that of correlating this knowledge with other determinants of occlusion and forming criteria and technics based upon this combined information. The solution to this problem becomes the primary purpose of this course and this manual. The pages which follow attempt to describe step by step all of the various elements associated with such a solution.

Occlusion cannot be intelligently discussed without first considering mandibular movement. Therefore, a further study of mandibular movement and the various factors governing this movement seems essential.

I. MANDIBULAR MOVEMENT

If the mandible merely opened and closed in a pure rotational movement occlusion would become an extremely simple problem to understand and to solve. Such is not the case. Rather, the mandible may rotate or translate in three planes; the sagittal, frontal, or horizontal. Its movement may encompass deviations in one or all of these planes, developing the potential for a complex interplay of movements. This, in part, explains the controversial history and current conflicting theories of dental occlusion. The complexity and significance of
the temporomandibular joint and its role in mandibular movement defies understanding in many minds.

The temporomandibular joint is the guidance mechanism responsible for mandibular movement. This joint, in the human, is a biarticular (left and right) ginglymus (sliding) joint. It is made up of two condyles (left and right) each resting in its glenoid fossa, with an articular disc interposed between these osseous components. This interosseous area consists, on both sides, of an upper synovial compartment, a disc or meniscus, and a lower synovial compartment. The joint is encased by the capsular ligament and further protected laterally by the temporomandibular ligament. This joint is most unique in that one side cannot be moved without influencing the other.

A joint is nature's way of providing a system capable of movement which wears at a minmum rate. A joint acts as an integral part of a lever system. Therefore, it follows that a discussion of levers is necessary in our study of mandibular movement.

II. LEVERS: (Fig. A-1,

Webster defines a lever as: "A rigid piece capable of turning about one point, or axis (the fulcrum), and in which are two or more points where forces are applied, used for transmitting and modifying force and motion: specific, a bar used to exert pressure, or sustain a weight, at one point of its length, by the application of a force at a second, and turning at a third on a fixed point called a 'fulcrum' ". Levers are classified as Class I, II, III, according to the variable relationship of the component factors; namely, the fulcrum (F), the power of force (P), and the work or weight (W). A Class I lever is the most efficient or it does the most work with the least applied force or power. The Class II lever is less efficient and the Class III is the least efficient of the three.
III. THE JAW LEVERS:

The jaw lever functions principally or, perhaps ideally, as a Class III lever. That is, the temporomandibular joint the fulcrum (F), the masseter, internal pterygoid, and temporalis muscles provide the bulk of the force (P), which is near the fulcrum, and the work is done by the teeth along the dental arches. (The digastric, mylohyoid, geniohyoid, infrahyoid, and external pterygoid muscles primarily act as depressors or openers of the mandible). The further anterior in the arch we go the less the efficiency of the Class III lever; or, we might say, the force exerted by the muscles results in less work load on the teeth. This helps us to understand why the anterior teeth, weak by structural design, are most frequently the last teeth lost. They are placed in a position to receive the least possible pressure on a leverage basis. Further, this furnishes an interesting observation concerning the cuspids. Here we have a very strong tooth, by anatomical and structural design, placed in an area of minimal leverage pressure. This fact supports the sequence of logic which establishes the cuspid tooth as a key anterior discluding factor.

As we have outlined, and as you may recall from the laws of physics, the Class II lever is a more efficient lever, and permits a greater force to be exerted on the work load, in our instance the teeth. Such a lever system is established in the mouth when we have balancing side contacts of the teeth, or cross arch work. As an example, the mouth is opened, the mandible is swung to the right for the mastication of food on the right side. At this moment the left condyle has progressed down the eminentia, the right condyle is seated firmly in its fossa, and the elevator group of muscles begin jaw closure. If, in this instance, the molar inclines on the left side contact we have a Class II lever established; i.e., the right condyle is the fulcrum (F), the left elevator muscles supply the power (P), and the teeth on the left side are between the two and represent the work load (W). Should the left molar contact, in this example, be severe enough it is conceivable that it could overpower the right condyle and become the fulcrum; thereby establishing a Class I lever which would permit a much greater devastating force on these teeth. These leverage factors, coupled with the fact that the forces created on the left molars are not in line with the long axis of the teeth, further explains the tragic damage that frequently occurs to the teeth and supporting structures when heavy balancing side contacts exist.

In the protrusive movement of the mandible there may be a pattern of occlusion develop which will also result in a Class I lever arrangement.
As the jaw opens, protrudes, and attempts to close in the incisal Edge position; if a heavy molar contact should exist, thereby preventing the anterior teeth from contacting for stability, the molars will overpower the condyles as the fulcrum (F), the power is supplied by the muscles behind these teeth (P), and the work load is transmitted to the anterior teeth, creating a Class I lever. Almost invariably, when we see severely worn anterior teeth, with moderate wear of the posterior teeth, this Class I lever system is present.

Another factor in occlusal design which may create an adverse leverage situation concerns the incisal angle vs. the angle of the eminentia.

When the mandible is positioned in the protrusive incisal edge to edge position, and it begins its power pattern to centric relation, if a degree of horizontal and, or, vertical overlap exists which creates an angle of anterior movement less than the angle of eminentia, a heavy molar contact will occur. (Fig. A-2).

Or, if eminentia), when horizontal and vertical overlap exists, a heavy molar contact will occur enroute to centric relation. The axiom for this situation would be; the incisal angle must be the same as (1:1 ratio) or greater than the angle of the eminentia to prevent heavy molar contact and the resultant destructive leverages.
From these examples we can readily see that leverage may play an extremely important role in occlusion. These are the scientific factors which help confirm the old adage that “if a patient does not have a harmonious occlusion, one of three things will occur:

A. A severe wear of the teeth.
B. A breakdown of the supporting structures.
C. Temporomandibular joint symptoms or muscle complaints.

IV. DYNAMICS OF MANDIBULAR MOVEMENT:

A. Muscles move the mandible.
B. Upholstered bone guides it.
C. Ligaments and fascia limit it (conceivably other anatomical structures such as the coronoid process are also limiting factors,)

V. PURPOSES OF MANDIBULAR MOVEMENT:

A. Functional
   1. Chewing (Mastication)
   2. Swallowing (Deglutition)
   3. Speech (Phonetics)

B. Nonfunctional or Parafunctional or Perverted
   1. Bruxism
   2. Clenching
   3. Habits (Pipe smoking, pencil biting, bobby pin opening, 'rid other habits)

If the mandibular movement were not used for the so-called nonfunctional or parafunctional purposes occlusion would become relatively unimportant. Dr. Harry Lundeen has presented portions of the following chart comparing the factors involved in functional vs. nonfunctional activity. Dr. Niles Guichet has suggested the term “perverted movements” rather than nonfunctional or parafunctional activity. This may be a more descriptive term and should be given serious consideration in future dental terminology.
VI. FUNCTION VS. NONFUNCTION OR PARAFUNCTION:

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>FUNCTION</th>
<th>NONFUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of tooth contact per day</td>
<td>4-10 min.</td>
<td>4 hours</td>
</tr>
<tr>
<td>Magnitude of applied force</td>
<td>20-40 lbs. per sq. in. vertical (accepted)</td>
<td>Up to 300 lbs. per sq. in. horizontal-lateral (injurious)</td>
</tr>
<tr>
<td>Direction of applied force</td>
<td>Class III (Maybe Cl. II)</td>
<td>Class II or Class I</td>
</tr>
<tr>
<td>Leverage</td>
<td>Isotonic</td>
<td>Isometric</td>
</tr>
<tr>
<td>Type of muscle contraction</td>
<td>Adaptive arc. Tooth interference avoided. cond. reflex</td>
<td>Skeletal arc. neuro-muscular protective mechanism absent</td>
</tr>
<tr>
<td>Proprioceptive influence or protection</td>
<td>C.O. or C.R.O.</td>
<td>Excentric</td>
</tr>
<tr>
<td>Mandibular closure position</td>
<td>None or at least minimal</td>
<td>Pathological changes occur-vary with different patients.</td>
</tr>
<tr>
<td>Pathological effects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Isometric muscle contraction may result in Poor blood circulation with a build-up of lactic acid which is conducive to muscle cramps, spasms, etc.*

From this chart it is easy to understand why functional activities are relatively unimportant and conversely why bruxism or parafunctional activities are so detrimental to the stomatognathic system. The time factor coupled with the direction of the applied force, leverage, etc. adequately explains the delaterious effects of bruxism. The statement that one night of bruxism is equal to a life time of chewing is probably more truth than fiction.
VII. THE MANDIBLE HAS FOUR DISTINCT MOVEMENTS:

A. Rotation ---pure rotation---opening and closing
B. Laterotrusion --- one condyle rotates while the other translates.
C. Protrusion --- both condyles move forward.
D. Transtrusion--- direct side shift --- Bennett movement.

Multiple combinations of these four basic movements occur.

VIII. THE MANDIBLE MOVES IN THREE PLANES:

A. Saggital Plane Movement --- Vertical Plane --- Opening and Closing

We study the following in this plane:

1. Envelope of motion (Posselt's diagram)
   a. Centric relation --- C. R.
   b. Centric occlusion --- C. O.
   c. Centric relation occlusion --- C. R. O.
   d. Rest position
   e. Opening & closing --- pathways & patterns

2. Hinge axis --- location and importance
3. Plane of occlusion
4. Curve of Spee
5. Lingual concavity of the maxillary teeth. The anterior tooth relationship --- overbite and overjet.
6. Mesial and distal tooth relationship --- Class I, II, III.
7. Angle of the eminentia

B. Axisorbital or Horizontal Plane Movement --- Horizontal Plane --- Protrusive and Lateroprotrusive

We study the following in this plane:

1. Bennett movement or transtrusion
2. Angle of the eminentia --- in relation to this plane
3. Protrusive movement
4. Ridge and groove direction on the teeth
5. Latero-retrusion vs. latero-protrusion
6. Intercondylar distance
C. **Coronal or Frontal Plane --- Vertical --- Translation**

We study the following in this plane:

1. Cusp height and fossa depth
2. Chewing cycle
3. Medio-lateral slant of the joint complex --- pitch
4. Latero-surtrusion vs. latero-detrusion
5. Bucco-lingual tooth relationship
6. Cross arch dimension --- width of the dental arch
7. Curve of Wilson
8. Intercondylar distance

**IX. FIVE DETERMINANTS OF MANDIBULAR MOVEMENT:**

<table>
<thead>
<tr>
<th>A. Posterior determinants,</th>
<th>Right T. M. J.</th>
<th>T. M. J. not under control of dentist except via oral surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Fixed joint</td>
<td>Left T. M. J.</td>
<td>Can be modified by dentist-phonetics and esthetics are limiting factors</td>
</tr>
<tr>
<td>C. Anterior Determinant Physiologic</td>
<td>Teeth</td>
<td>Can be directly modified to a degree by modifying the third determinant (the teeth)</td>
</tr>
<tr>
<td>D. Proprioceptive neuro-muscular mechanism</td>
<td>T. M. J., pulps, and perio. tissues send nerve impulses to muscles to work (Cond. reflex)</td>
<td>Emotional stress contributes to bruxism, muscle spasms, T. M. J. complaints, etc.</td>
</tr>
<tr>
<td>E. Emotional status, stress or tension of patient</td>
<td>Central nervous system (C. N. S.)</td>
<td></td>
</tr>
</tbody>
</table>

---
X. ARCS OF MANDIBULAR CLOSURE:

A. Skeletal Arc of Closure:

The skeletal arc of closure is determined by the skeletal structures and the C. N. S. We believe it is the arc of closure the mandible would like to take if there were no tooth interferences or deflection. This closure is into centric relation or the terminal hinge position. The functional act of swallowing occludes the teeth in this position on this arc of closure.

B. Adaptive Arc of Closure:

The adaptive arc of jaw closure is an arc directed by a conditioned reflex. The entire proprioceptive neuromuscular mechanism sets up the conditioned reflex and guides this arc of closure. Such closure is into centric occlusion or maximum intercuspation of the teeth. This adaptive arc of closure is the one used in chewing or when you tell a patient to close his back teeth together. Such an arc of closure could be considered as nature's protective mechanism since the arc can be changed by various stimuli thus altering the conditioned reflex. If a tooth becomes sensitive, either pulpaly or periodontally, the neuromuscular mechanism will program a new conditioned reflex to protect the involved tooth. This adaptive arc does not necessarily occur only in the sagittal plane. Concomitantly it may occur in other planes visualized as lateral deviations. This arc of closure is sometimes referred to as "habit centric", etc.

C. Voluntary Arc of Closure:

There is a voluntary arc of closure or voluntary control over mandibular movement which is normally never used. This type of movement requires thought and, therefore, cannot be carried out over long periods of time. This may be likened to voluntary control over respiration; we can consciously hold our breath or breathe faster or slower for a limited time only. Such a voluntary arc of jaw closure is considered of little significance since it is rarely used.
XI. WHY NOT TWO ARCS OF CLOSURE?

Ideally the skeletal arc of closure (C.R.O.) and the adaptive arc of closure (C. 0.) should coincide. Clinically, dental investigators in many disciplines of dentistry seek to establish a coincidence of C. 0. and C. R. 0. Complete denture prosthodontists have established that slower ridge reabsorption occurs, greater chewing efficiency results, and greater stability of the denture bases exist, when denture patients are provided with a coincidence of C.O. and C. R. 0..

Investigation by periodontists has established that a greater potential for preservation of supporting structures results and more rapid healing of diseased tissues occurs when a coincidence of C. 0. and C. R. O. exists.

Detrimental effects of various magnitude may occur when these two arcs of closure do not harmonize. The degree of these effects will vary from individual to individual, dependent upon many factors which we do not at this time fully understand, but which we categorize as patient adaptability.

When detrimental effects do occur, we can summarize the causes and define the logic of their occurrence as follows:

A. The conservative Class III lever system is most efficient when the condyles are braced in their terminal hinge position. Whereby minimum muscle load produces maximum work.

B. When these two arcs of closure do not coincide a hit and slide frequently exists between C.R. 0. and C.O. This is termed deflective malocclusion.

C. This slide introduces adverse forces or forces not in line with the long axis of the teeth.

D. These adverse forces tend to accentuate periodontal problems.

E. The resultant deflection is conducive to wear and instability of the teeth in the dental arch.
F. This deflection also tends to predispose to muscle tension and spasms or other complaints associated with T. M. J. problems.

G. Two arcs of closure coupled with emotional stress appears conducive to bruxism or clenching habits.

H. Two arcs of closure lead to two different vertical dimensions of occlusion which in turn, may result in muscle inefficiency.

I. It has never been conclusively proven whether parafunctional activities are initiated from C. R. 0. or C.O. Therefore, it would seem imperative that these two positions coincide in order to accommodate parafunctional as well as functional lateral excursions. If C. R. 0. and C. 0. are not made to coincide all lateral excursive excursions are apt to be in conflict with the T. M. J. guidance.

J. C.R. is the only maxillo-mandibular relationship that can be routinely repeated. Therefore, it would seem logical to have C. R. 0. and C.O. coincide in order to maintain a more constant anatomical relationship between the jaws and consequently between the teeth in occlusion.

**IDEAL OCCLUSION**

Prior to discussing the various concepts of occlusion per se, we should first ascertain if there is such a thing as ideal occlusion. If so, what are the criteria or prerequisites for such an occlusion? Some authors reject the term "ideal occlusion" and substitute for it a pair of opposites, "pathological vs. physiological occlusion". We prefer to think that there must be some type of occlusion that is optimum. Keep in mind that the word *ideal* is something like *infinity* in that it can be approached but never actually reached. All other occlusions regardless of what they might be named, would be but points located somewhere along the line toward ideal occlusion.
Many patients present themselves, to the dental office, with obvious malocclusion; however, they have no dental complaints associated with malocclusion or occlusal disease. As a result of this common observation many dentists have subscribed to a theory of physiological vs. pathological occlusion. By pure definition a physiologically acceptable occlusion is one free of patient complaints and recognizable pathological conditions, by the dentist, at the time of examination.

In subscribing to such a theory we would do nothing to equilibrate or otherwise alter any occlusion which is physiologically accepted by the patient. However, how can anyone say that what is physiologically acceptable today will not become pathological tomorrow, next month, or next year? There are many factors which permit such a malocclusion to be physiologically acceptable to the patient. The absence of adverse C. N. S. influence or emotional tension or stress is probably the major factor. The age of the patient, local and general health, tissue tone and tolerance, oral hygiene, are some of the other factors. Any one of these factors can change at any time; therefore, it would seem logical to establish criteria for an ideal occlusion. Such criteria could then be used as a yardstick to evaluate and analyze technics and concepts of occlusion. Also prophylactic equilibration or alteration of existing occlusion in these patients might be indicated. Great care must be exercised when altering a physiologically accepted occlusion. In some instances the balance between acceptance and rejection will be very slight. Intervention by the dentist may be the trigger mechanism for tooth consciousness and the resulting sequellae.
Whatever your thoughts on this subject may be, whichever terminology is preferred, there must be a goal or criteria for the occlusion we strive to attain. The mere fact that patients present themselves with recognizable pathological occlusions or symptoms associated with occlusal disease stresses such a need. These patients must be treated and their occlusions must be altered in an attempt to correct the situation. Therefore, some criteria are essential. In addition to those patients with occlusal pathosis other patients require extensive restorative treatment due to dental caries, missing teeth, drifting of the teeth, or advanced periodontal problems. Therefore, many patients, by necessity, must receive restorative treatment with alterations of their existing occlusion. This further necessitates the formulation of some criteria for an ideal occlusion. By the same token, if such an occlusion proves beneficial to these patients then it would seem logical that minor prophylactic alterations in occlusion might be indicated in those patients who are not in demonstrable trouble at the time. Apply the old adage that "an ounce of prevention is worth a pound of cure".

I. WHAT CONSTITUTES OCCLUSAL DISEASE:

The complaints and recognizable pathosis associated with occlusal disease, to which we have referred, could be listed as follows:

A. Temporomandibular joint problems such as pain, crepitus, subluxation, clicking, etc.

B. Spasms or muscle complaints associated with any of the muscles related to mandibular movement.

C. Other referred type pain associated with either T. M. J. or muscle complaints. (head, neck and shoulders)

D. Excessive wear of the occlusal or incisal surfaces of the teeth.

E. Bruxism, clenching, or grinding habits.

F. Periodontal pathosis.

To reiterate; whatever your thoughts on this subject may be, whichever terminology you prefer, whatever the reason for altering an occlusion, we must establish certain prerequisites and criteria for the occlusion we will strive to attain.
In general criteria for such an occlusion may be listed as follows:

II CRITERIA FOR AN IDEAL OCCLUSION

A. Everything we do must aim towards a minimum of muscle tension or exertion to obtain maximum efficiency.

B. The stresses or forces should be directed in line with the long axis of the teeth. Adverse or lateral forces must be eliminated.

C. The end result should be comfortable to the patient, he should be as unconscious as possible of the actual presence of teeth in his mouth.

D. Stability of the teeth in the dental arches, the teeth should not become loose, migrate or otherwise change position adversely following treatment.

E. All of the component elements involved in occlusion should be in harmony with each other. No single component should dictate or become master over the other components in any jaw position.

F. A minimum of wear or degeneration and a maximum of health of all of the elements involved should follow completion of the treatment.

G. Proper contact, contour, and external tooth form should be achieved to maintain periodontal health in addition to occlusion per se.

H. A narrow occlusal table should be attempted to better direct the forces over the long axis of the teeth to improve efficiency in function.

I. The teeth should not be locked into any position, freedom of all excursive movements are essential.

J. The skeletal arc of closure (C. R. O.) and the adaptive arc of closure (C. O.) should harmonize.

K. The initial contact of the posterior teeth should be uniform in character and exactly at the same time. No tooth contact should either direct or deflect such closure.

L. All centric holdings cusps should contact their counterparts evenly. Ideally, the buccal cusps of the mandibular teeth and the lingual cusps of the maxillary teeth are referred to as the centric holding cusps.

M. This initial contact should be a multiplicity of small points rather than large areas of tooth contact.

N. This initial contact should occur at the most closed vertical dimension, which is the established vertical dimension for any specific case.
0. The teeth should be free to function as groups without interference from another group.

1. The incisors should be permitted to cut or incise very thin foods, such as lettuce, without posterior interference.

2. The cuspids should be free to hold or tear foods efficiently without posterior or incisor interference.

3. The posterior teeth should shred and grind food efficiently without anterior interference, either incisors or cuspids.

P. Vertical dimension must permit a physiological rest position with available free way space.

Q. The anterior teeth must be given consideration to harmonize the occlusion. The proper lingual concavity of the maxillary anterior teeth is an essential ingredient along with the inter-relationship of the mandibular anterior teeth.

FACTORS FOR CONCEPTS OF OCCLUSION

I. TYPES OF OCCLUSION:

A. Bilateral Balanced Occlusion:

Early research on occlusion was carried out primarily by the complete denture prosthodontists. Since the teeth in complete dentures are locked together into one unit it is possible to dislodge one side of the complete denture if heavy contact exists on the opposite side. For this reason these prosthodontists formulated the bilateral balanced type of occlusion. Since most of the research on occlusion was orientated to this field of dentistry, its influence carried over to the treatment of the natural dentition. Therefore, the majority of the early concepts and technics of occlusion incorporated the bilateral balance type of tooth contact into their philosophy of natural tooth occlusion. As a result the earlier concepts had many failures because they rebuilt the patient’s occlusion to this type of tooth contact.

It has now been generally accepted that bilateral balanced occlusion can only be used for complete denture occlusion. Even the prosthodontists no longer strictly adhere to the theory that it is necessary to have all of the teeth on the balancing side maintain contact; usually only one molar is considered sufficient.
Later research conducted primarily by the periodontists has shown that balancing side tooth contact is extremely destructive to the supporting structures. As a result of this as well as other research and observation, bilateral balanced occlusion is no longer recommended for natural tooth occlusion.

1. Prerequisites for Bilateral Balanced Occlusion

a. Centric Position shall have all the posterior teeth contact evenly when the jaws are closed into centric relation (C. R. 0.). The anterior teeth shall just barely miss. An exception being an end-to-end Class III jaw relationship; here the anterior teeth would contact along with the posterior teeth in C.R. 0.

b. Eccentric Positions

(1) Laterotrusion

(a) Working Side Test Position shall have the maxillary buccal cusp inclines in even contact with the mandibular buccal cusp inclines on the working side. The working side is the side of the rotating condyle.

(b) Balancing Side Test Position. The teeth on the opposing side or the side opposite the working side shall have a balancing contact between the lingual cusps of the maxillary teeth and the buccal cusps of the mandibular teeth. The balancing side is the side opposite the working side or the side of the orbiting condyle.

(2) Protrusive Test Position is that position in which the incisal edges of the maxillary six anteriors are in contact with the incisal edges of the mandibular eight anterior most teeth. This test position shall have a last molar balancing contact; usually the mesiolingual cusp of the maxillary last molar contacts the distal marginal ridge of the mandibular last molar tooth.
B. Unilateral Balanced Occlusion

After research established that balancing side contacts were destructive to natural dentitions the bilateral balanced idea was abandoned for dentulous mouths. Many dentists at that time, merely eliminated the balancing contact statements from the old theory and maintained the remainder of the bilateral balanced occlusion theory per se. Thus, the unilateral balanced occlusion theory of tooth contact was born.

1. Prerequisites for Unilateral Balanced Occlusion:

   a. Centric Position shall have all the posterior teeth contact evenly when the jaws are closed in centric relation (C. R. 0.). The anterior teeth may or may not contact in this position.

   b. Excentric Positions

      (1) Laterotrusion

         [a] Working Side Test Position shall have the maxillary buccal cusp inclines in even contact with the mandibular buccal cusp inclines on the working side. The working side again being the side of the rotating condyle.

         [b] Balancing Side Test Position. There shall be no tooth contact what-so-ever on the side opposite the working side or the balancing side.

      (2) Protrusive Test Position. There shall be no posterior tooth contact what-so-ever when the maxillary six anterior teeth are contacting the mandibular eight anterior teeth, edge to edge, in the protrusive test position.

C. Disclusion

At the time bilateral balanced occlusion was abandoned for natural teeth another group of dentists came up with a completely different ideal for an occlusion of natural teeth. They noticed the prominence of the cuspid tooth in meat eating animals (including man) and concluded that one purpose of the cuspid was to disclude or separate all the posterior teeth during excentric movements. As a result of these observations the third type of tooth contact relationship was formulated and named
"disclusion". The rationale of such an occlusion will be discussed in detail later.

I. The Prerequisites for Disclusion:

a. **Centric Position** shall have all the posterior teeth contact evenly when the jaws are closed in centric relation or terminal hinge position. The anterior teeth shall just barely miss in this position.

b. **Excentric Positions**

   (1) **Laterotrusion**

      (a) Working Side Test Position shall have, whenever possible, the maxillary cuspid in contact with the mandibular cuspid edge to edge in this test position. It is permissible to have other anterior teeth in contact when in this position. No posterior teeth shall contact anytime, anywhere, once the jaw leaves centric relation position.

      (b) Balancing Side Test Position. There shall be no tooth contact whatsoever on the balancing side or the orbiting condyle side.

   (2) **Protrusive Test Position**. There shall be no posterior tooth contact whatsoever when any of the maxillary six anteriors contact any of the mandibular eight anteriors, in any degree of protrusive movement.

II. **TYPES OF CUSP PLACEMENT**

A. **Cusp To Embrasure**:

This is the type of cusp placement as established in the old ideal complete denture set up; variations from this relationship are most frequently seen in the natural dentition. It is basically a tooth to two teeth relationship of all the teeth except the mandibular central incisor and the maxillary last molar. Each maxillary tooth is distal and buccal to its corresponding lower counterpart.
1. Centric Position:

<table>
<thead>
<tr>
<th>LOWER BUCCAL CUSP</th>
<th>CONTACT AREA OF MAXILLARY-TEETH (Fig. A-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st bicuspid</td>
<td>embrasure between cuspid - 1st bi.</td>
</tr>
<tr>
<td>2nd bicuspid</td>
<td>embrasure between 1st bi. - 2nd bi.</td>
</tr>
<tr>
<td>1st molar (M. B. cusp)</td>
<td>embrasure between 2nd bi. - 1st molar</td>
</tr>
<tr>
<td>1st molar (D. B. cusp)</td>
<td>distal fossa of max. 1st molar</td>
</tr>
<tr>
<td>1st molar (D. cusp)</td>
<td>embrasure between 1st - 2nd molars</td>
</tr>
<tr>
<td>2nd molar (M. B. cusp)</td>
<td>central fossa of max. 2nd molar</td>
</tr>
<tr>
<td>2nd molar (D. B. cusp)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. A-3

From this we can readily see that all the mandibular buccal cusps are in an embrasure contact relationship with the maxillary teeth except:

a. The D. B. cusp of the mandibular 1st molar which contacts the central fossa of the maxillary 1st molar.

b. The D. cusp of the mandibular 1st molar which contacts the distal fossa of the maxillary 1st molar.

c. The D. B. cusp of the mandibular 2nd molar which contacts the central fossa of the maxillary 2nd molar.
<table>
<thead>
<tr>
<th>MAXILLARY LINGUAL CUSP</th>
<th>CONTACT AREA OF THE MANDIBULAR TEETH (Fig. A-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st bicuspid</td>
<td>distal fossa of lower 1st bicuspid</td>
</tr>
<tr>
<td>2nd bicuspid</td>
<td>distal fossa of lower 2nd bicuspid</td>
</tr>
<tr>
<td>M. L. cusp of 1st molar</td>
<td>central fossa of lower 1st molar</td>
</tr>
<tr>
<td>D. L. cusp of 1st molar</td>
<td>embrasure between 1st - 2nd molar</td>
</tr>
<tr>
<td>M. L. cusp of 2nd molar</td>
<td>central fossa of lower 2nd molar</td>
</tr>
<tr>
<td>D. L. cusp of 2nd molar</td>
<td>embrasure distal to lower 2nd molar</td>
</tr>
</tbody>
</table>

Fig. A-4

From this we can see that all of the maxillary lingual cusps are in a fossa relationship except:

a. The D. L. cusp of the maxillary 1st molar contacts in the embrasure between the mandibular 1st and 2nd molars.

b. The D. L. cusp of the maxillary 2nd molar is not actually in contact but is in a relationship to the embrasure distal to the mandibular 2nd molar.
2. Excentric Positions

a. Laterotrusion

(1) **Working Test Position: Buccal Cusps** (Fig. A-5)

The working test position shows all of the mesial and distal inclines of the buccal cusps to be in an interdigitation type relationship with its corresponding counterpart, in the opposing arch. All of the maxillary buccal cusp tips are in an embrasure relationship except:

(a) The M. B. cusp tip of the maxillary 1st molar is in the B. development groove of the mandibular 1st molar.

(b) The D. B. cusp of the maxillary 1st molar is in the disto-buccal developmental groove of the mandibular 1st molar.

(c) The M. B. cusp of the maxillary 2nd molar is in the B developmental groove of the mandibular 2nd molar.

All of the mandibular buccal cusps are in an embrasure relationship except:

(a) The D. B. cusp tip of the mandibular 1st molar is in the B developmental groove of the maxillary 1st molar.

(b) The D. cusp tip of the mandibular 1st molar contacts the distal incline of the D. B. cusp of the maxillary 1st molar.

(c) The D.B. cusp tip of the mandibular 2nd molar is in the B developmental groove of the maxillary 2nd molar.
(2) Working Test Position: Lingual Cusps (Fig. A-6)

The working test position also shows all of the mesial and distal inclines of the lingual cusps to be in an interdigitation type relationship with their counterparts, in the opposing arch. All of the maxillary lingual cusps are in a fossa relationship except:

(a) The D. L. cusp of the maxillary 1st molar is in the embrasure between the mandibular 1st and 2nd molars.
(b) The D. L. cusp of the maxillary 2nd molar is in the embrasure distal to the mandibular 2nd molar.

All of the mandibular lingual cusp tips are in an embrasure relationship except:

(a) The D. L. cusp of the mandibular 1st molar is in the lingual developmental groove of the maxillary 1st molar.
(b) The D. L. cusp of the mandibular 2nd molar is in the lingual developmental groove of the maxillary 2nd molar.
B. Cusp to Fossa:

This type of cusp placement locates the mandibular buccal cusps into the fossa of their maxillary counterparts. The maxillary lingual cusp are positioned into the fossa of their mandibular counterparts.

A cusp fossa relationship better directs the forces over the long axis of the teeth. It further tends to stabilize individual tooth position and maintain the teeth in their respective positions in the dental arches. It also tends to prevent food impaction between the teeth since there are no cusp tips striking in the embrasures to force the teeth apart and to impact the food into the gingival papillae. There is less tendency to wear the cusp tip per se which also tends to enhance the stability of the teeth in the dental arch.

Ideally, a cusp to fossa relationship is a tooth to tooth contact rather than a tooth to two teeth arrangement. It can obviously also be a tooth to two teeth relationship.

1. Centric Position:

<table>
<thead>
<tr>
<th>LOWER BUCCAL CUSPS</th>
<th>CONTACT AREA OF MAXILLARY TEETH (Fig. A-7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st bicuspid</td>
<td>mesial fossa of max. 1st bicuspid</td>
</tr>
<tr>
<td>2nd bicuspid</td>
<td>mesial fossa of max 2nd bicuspid</td>
</tr>
<tr>
<td>1st molar (M. B. cusp)</td>
<td>mesial fossa of max. 1st molar</td>
</tr>
<tr>
<td>1st molar (D. B. cusp)</td>
<td>central fossa of max. 1st molar</td>
</tr>
<tr>
<td>1st molar (D. cusp)</td>
<td>distal fossa of max. 1st molar</td>
</tr>
<tr>
<td>2nd molar (M. B. cusp)</td>
<td>mesial fossa of max. 2nd molar</td>
</tr>
<tr>
<td>2nd molar (D. B. cusp)</td>
<td>central fossa of max. 2nd molar</td>
</tr>
</tbody>
</table>
MAXILLARY LINGUAL CUSPS

1st bicuspid
2nd bicuspid
1st molar (M. L. cusp)
1st molar (D. L. cusp)
2nd molar (M. L. cusp)
2nd molar (D. L. cusp)

CONTACT AREA OF MANDIBULAR TEETH (Fig. A-8)

distal fossa of mand. 1st bicuspid
distal fossa of mand. 2nd bicuspid
central fossa of mand. 1st molar
distal fossa of mand. 1st molar
central fossa of mand. 2nd molar
distal fossa of mand. 2nd molar

Fig. A-7

Fig. A-8
2. **Excentric Position**

   a. **Laterotrusion**

   (1) **Working Test Position: Buccal Cusps** (Fig. A-9)

   The working test position shows an interdigitation of the mesial and distal inclines of the buccal cusps, however, they are not in an embrasure relationship. The bicuspid notches are located on the mesial inclines of the maxillary buccal cusps and the distal inclines of the mandibular buccal cusps. The maxillary molar cusp tips glide through the developmental grooves of the mandibular teeth. The mandibular buccal cusps glide through accessory or supplemental grooves on the buccal cusps of the maxillary molars.

   ![Fig. A-9](image-url)
(2) Working Test Positions: Lingual Cusps (Fig. A-10)

The working test position shows a relationship of the mesial and distal inclines of the lingual cusps similar to that of the buccal cusps.

Fig. A-10

C. Tooth Contact According to Jaw Positions:

1. Centric Relation Occlusion: (C. R. 0.)

This type of tooth contact harmonizes the skeletal and adaptive arcs of jaw closure so that they coincide and are one and the same; C. R. 0. equals C.O. The reasons for having these arcs of closure coincide have been listed in the previous pages when discussing mandibular movement.

2. Centric Relation Occlusion: (C. R. 0. Plus Centric Occlusion (C. O.))

This type of tooth contact orients the patient's occlusion to centric relation or terminal hinge position. It then, in addition, maintains centric occlusion or the adaptive arc of closure. Harmony between the two positions is provided, so that there is no deflection between C. R. 0. and C.O. This harmony is frequently referred to as "long centric".
3. Centric Occlusion (C.O.):

As previously mentioned many men believe in the theory of physiological vs. pathological occlusion. These men do not believe in changing the physiologically accepted occlusion. They would build any necessary restorations to the existing maximum intercuspation of the teeth or C.O. Further, they wouldn't equilibrate the patient who presents himself with a physiologically accepted occlusion. This area was discussed in some detail in the section on ideal occlusion. This theory certainly seems grossly inadequate since many patients have an existing pathological occlusion. For this and many other reasons, previously mentioned, such an approach should only be accepted for children whose occlusion hasn't been finalized due to incomplete growth and development.

### SUMMARY OF FACTORS FOR CONCEPTS OF OCCLUSION

<table>
<thead>
<tr>
<th>TYPES OF OCCLUSION</th>
<th>TYPES OF CUSP PLACEMENT</th>
<th>TYPES OF TOOTH CONTACT ACCORDING TO JAW POSITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral balanced occlusion</td>
<td>Cusp to embrasure</td>
<td>C. R. O.</td>
</tr>
<tr>
<td>Unilateral balanced occlusion</td>
<td>Cusp to fossa</td>
<td>C.R. O. plus C.O.</td>
</tr>
<tr>
<td>Disclusion</td>
<td></td>
<td>C.O.</td>
</tr>
</tbody>
</table>

From this summary we can readily see that there are eighteen mathematical possibilities or combinations available upon which to formulate possible concepts or theories of occlusion.

We have already eliminated the bilateral balanced type of occlusion for the dentulous patient; it is only applicable for complete denture construction. We have dispensed with C.O. type of tooth contact except for children's dentistry; it has been shown to be grossly inadequate for adult dentitions. Several significant reasons have been presented in favor of a cusp fossa type cusp placement over a cusp to embrasure placement.
Consequently, by the elimination of these three factors we decrease the mathematical possibilities considerably. As a matter of fact, the only logical remaining combinations are the four as follows:

1. C. R. O.  
   Unilateral Balanced ----> Cusp to fossa.

2. C. R. O. + C. O.  
   Occlusion

3. C. R. O.  
   Disclusion -------------> Cusp to fosses.

4. C. R. O. + C. O.  

By such a process of elimination we have arrived at four combinations of factors upon which logical concepts of occlusion may be formulated. In actuality we only have two main concepts which have evolved out of these remaining four possibilities.

I. PANKEY-MANN-SCHUYLER ----> Unilateral balanced occlusion ---  
   Cusp to Fossa - C. R. O. plus C.O.

II. GNATHOLOGY ------------------------> Disclusion --- Cusp to Fossa---  
   C. R. O.

THIS IS WHERE WE ARE CONCERNING OCCLUSION AT THE PRESENT TIME . . .