OCCLUSION

Occlusion may be defined as:” The contact of the opposing surfaces of teeth of the two jaws”.

T M J:

The craniomandibular articulation (fig.1) and the capabilities of movements and limitations of the TMJ are very important to the dental profession, especially in the field of Prosthodontics. This is due to the fact that there is a relationship between the motion of the condyles and the positioning of artificial teeth and the allowable occlusal morphology of restored teeth.

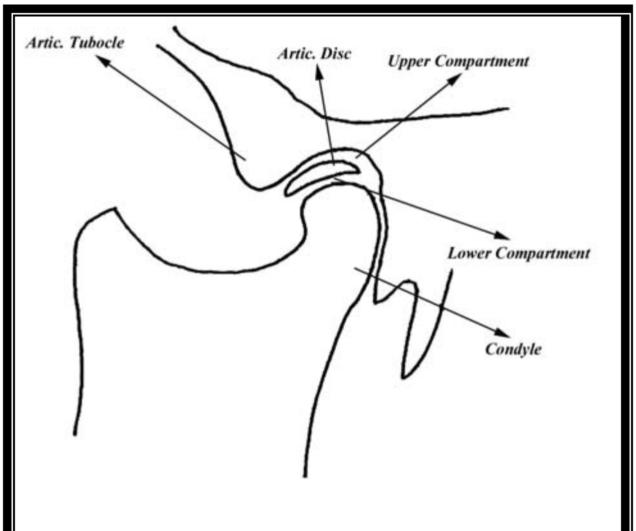


Fig.1:

Anatomy

1 -Condyle

2-Glenoid Fossa

3- Articular Disc

Description

Compound: composed of three or more bones. Although the articular disc is not a bone, it functions as one.

Diarthrodial: it can perform gliding movements without axial motion.

Type of Articulation:

Ginglymoarthrodial: it is capable of producing ginglymoid action by rotation around the transverse axis (opening and closing). It is also capable of diarthroidal action by translation of the articular disc and the condyle in their relation to the articular fossa.

The mandible therefore is capable of moving both by rotation and translation, either singly or in combination.

Neuro Muscular System:

– Muscles of Mastication:

Masseter

Temporalis

Lateral Pterygoid

Medial Pterygoid

– TMJ Capsule

– Associated Ligaments

Tempromandibular

Sphenomandibular

Stylomandibular

Definitions:

Centric Relation:

Centric relation is a bone-to-bone relation. It is the relation between the maxilla and the mandible when the Condyles are in the rear most upper most mid most in the Glenoid fossae (known as the "rum" position). It is a relation where the condyle is in a hinge position.

It may also be defined as the untranslated hinge position of the mandible in its relation to the maxilla. More simply, it may be defined as the physiologic centering of the condyles in the cranium. At this centered position, there is an absence of translation.

The most recent definition is that "the centric relation is the maxillo-mandibular relationship in which the condyles articulate with the thinnest avascular portion of their respective disks with the complex in the anterior-superior position against the shapes of the articular eminencies".

Centric Occlusion:

This is a relation between the lower and the upper teeth, that is, it is a tooth-to-tooth relation.

Defined as being the occlusion of teeth as the mandible closes in centric relation. It is a reference point from which all other relations are eccentric.(fig 2)

Fig.2:

Maximum Intercuspation:

It is the most closed complete interdigitation of mandibular and maxillary teeth irrespective of condylar centricity.

In other words, maximum intercuspation may or may not coincide with centric occlusion, depending on the position of the condyle. If in maximum intercuspation the condyles are physiologically centered, then both the maximum intercuspal position and the centric occlusion position are the same. However, if maximum intercuspation occurs with the condyles being out of centricity, then both positions would not coincide, with the maximum intercuspation in that case, referred to as the habitual closure, and is considered as an eccentric position. In that case the intercuspal position is in a position forward to the centric position, and at a lower vertical dimension.

Condylar Movements

1-Rotation

Rotation is the motion of a body around its axis. Mandibular rotation occurs in the lower compartment of the T M J, between the mandibular Condyle and the articular disc. Mandibular rotation occurs around the rotational centers of the condyles. (fig 3)

Fig.3:

The Hinge Axis: is the imaginary line connecting the rotational centers of one condyle with that of the opposite condyle, and around which the mandible makes the opening and closing rotational movements. (fig 4)

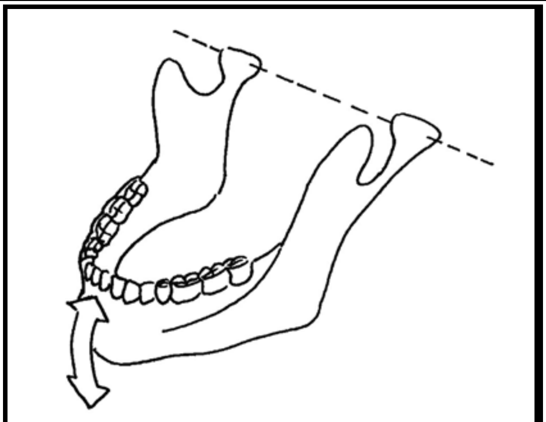


Fig.4:

2-Translation

Translation is the movement of a body when all its parts move at the same time. Mandibular translation occurs in the upper compartment of the T M J between the disc and the glenoid fossa. (Fig 5)

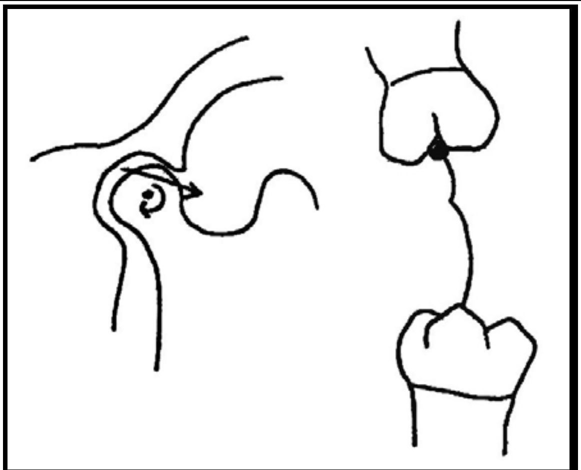


Fig.5:

In mandibular translation, there is a change in the relationship of the condyle and its articular disc with the articular fossa.

Mandibular Movements

With the condylar rotation and translation, the mandible is capable of performing the following movements:

1-Opening
2-Protrusive
3-Lateral Excursions: right and left

For studying the mandibular movements, we will always start from the starting point of centric occlusion.

A-Opening Movement

For this movement to occur, the condyle rotates in its place, in the terminal hinge position. Pure rotation occurs only till the condyles start to translate moving out of its centricity. Upon rotation of the condyle, the mandible opens, and teeth are discluded.

As soon as the pure rotation ends, the condyle begins to translate, moving forward and downward on the superior and anterior

walls of the glenoid fossa, with the arc of opening changing, and the mandible opening further till the maximum opening position.

B-Protrusive Movement

For this movement to occur, Condyles follow the form of the superior wall of the glenoid fossa, they slide downwards and forwards as the mandible moves in protrusion. This movement causes the separation of the posterior teeth, a state known as **Disclusion.** (Fig 6)

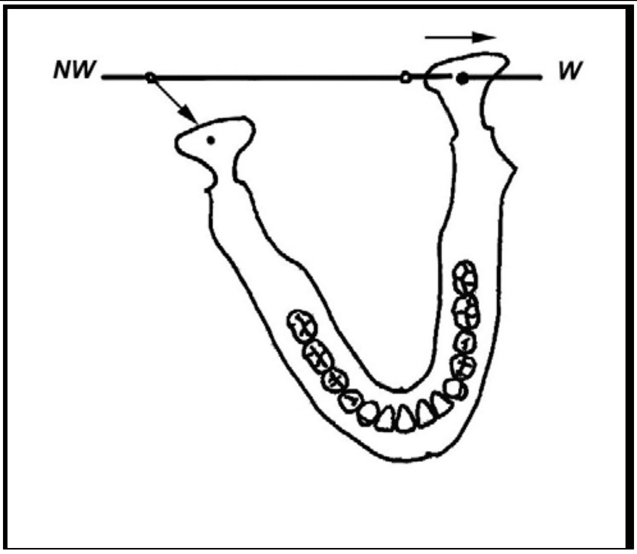
Fig.6:

During this movement, the opposing inclines of the teeth should not touch each other. The palatal cusp of the upper molar travels distally from its centric position in the central fossa of the lower opposing tooth, while the buccal cusp of the lower travels mesially across the central groove of the upper opposing tooth.

The cusp angle should be in harmony with the angle that the condyle travels during the protrusive movement, or else a protrusive interference would exist. The steeper this angle, the more allowable cuspal angle, the longer the cusps and the deeper the fossae.

C-Lateral Excursion Movement

The mandible is capable of moving towards both the right and left sides. The side to which the mandible moves is called the working side, while the opposite side is called the non-working side. (fig 7)



The Working Side (fig 8)

This is the side on which we chew. The condyle on the working side is called the rotating condyle. It rotates in its fossa with a little downward and backward movement, rotating against the superior and posterior walls of the glenoid fossa.

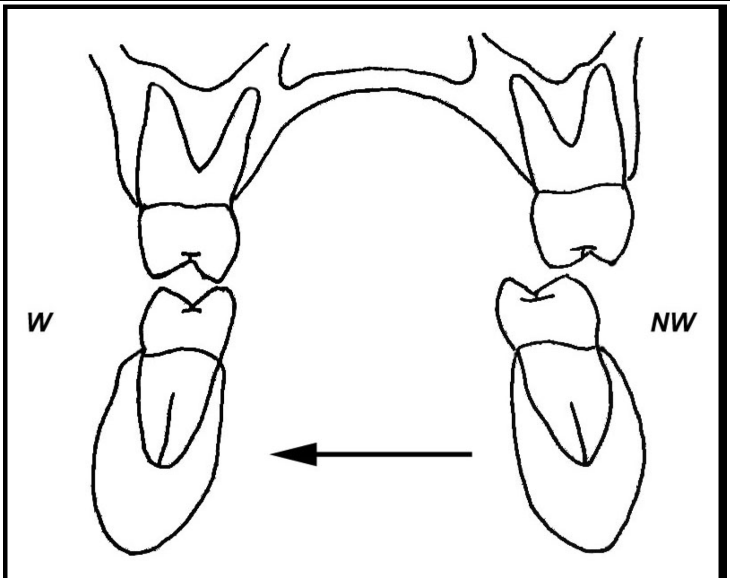


Fig.8:

The buccal cusps of upper and lower molars line up, with the lower buccal stamp cusp moving from its centric position in the fossa of the opposing upper tooth towards the buccal along the buccal groove, while the upper stamp cusp move lingually along the lower lingual groove.

During this movement, any contact that would exist between the lower buccal cusps or the upper palatal cusps with their opposers would be considered as working side interferences.

The Non-Working Side (fig 8)

This is the side opposite to where we chew. The condyle on the non-working side is called the orbiting or translating condyle. The condyle moves medially till it comes in contact with the medial wall of the glenoid fossa, then moves downwards, forwards and medially, on the superior and medial walls of the fossa.

The palatal cusps of upper molars line up with the buccal cusps of lower molars. The buccal cusps of the lower teeth moving lingually, from their centric position across the oblique palatal grooves of their

upper opponent, while the upper palatal cusps move buccally through the oblique buccal grooves of their lower opponent.

During this movement, any contact that would exist between the lower buccal cusps or the upper palatal cusps with their opposers would be considered as non-working side interferences.

Bennett Movement (Side Shift)

This is the lateral bodily movement of the rotating (working) condyle, with medial movement of the orbiting (non-working or translating) condyle.

The medial wall of the glenoid fossa on the non-working side determines the amount of this movement. The non-working condyle moves medially till it is in contact with the medial wall.

The Initial side shift: occurs during the initial 2 mm of the anterior movement. The average initial side shift is 1.7mm medially. There is more medial movement than there is anterior movement .The Progressive side shift: occurs after the initial side shift, the curve of the medial wall of the glenoid fossa begins to straighten, there is more anterior movement with little medial movement

Total side shift = Initial side shift + Progressive side shift

The Bennett Angle: angle formed between the mid-sagittal plane and the medial wall of the glenoid fossa on the non-working side (7-8 degrees)

Determinants of Occlusion

1-The Posterior Determinants of Occlusion:

The effect of the anatomy of the TMJ on the mandibular movements and tooth morphology

The paths of the condyles take during their movements within the glenoid fossae, and the locations of the rotational centers determine the occlusal morphology of teeth. These have an effect on the allowable cusp height, fossa depth along with the acceptable ridge and groove directions.

A- Protruding Condyle (Antero-posterior movement)

In a protrusive movement, the condyle rotates initially and then rotates and translates, moving downwards and forwards guided by the angle of the articular eminence.

The steeper the angle of the articular eminence, the more allowable cusp height, the steeper the cusp angles and the deeper the fossae.(fig 9)

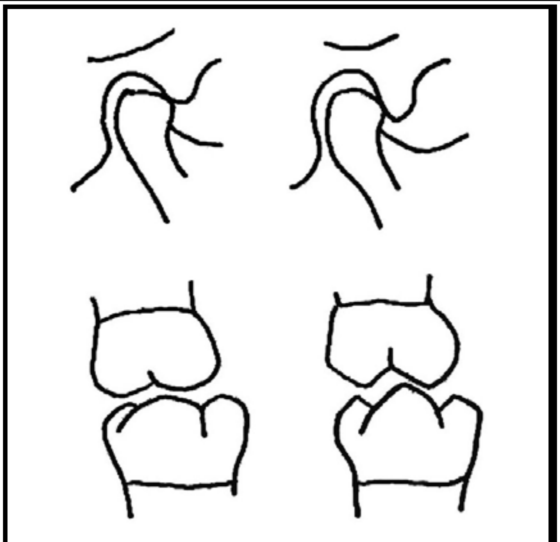


Fig.9:

B-Rotating Condyle (Working Side movement)

On the working side, the rotating condyle rotates and translates on the posterior and superior walls of the fossa. The stamp buccal cusp of the lower molar should be able to pass through the buccal working groove of the upper molar without contact, while the upper stamp palatal cusp of the upper pass without contact through the lower lingual working groove.

From a Frontal view, the effect of the **superior wall** of the fossa can be seen. The steeper of the superior wall, the more the allowable cusp height, the steeper the cuspal angle and the deeper the fossae and the grooves. (fig 10)

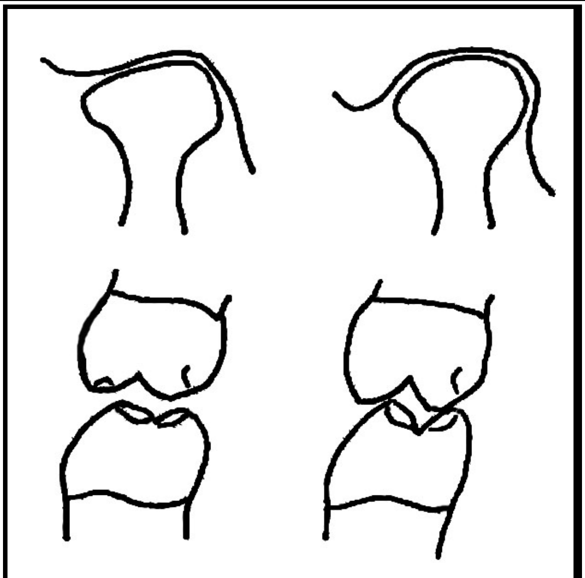


Fig.10:

A steeper angle of the superior wall would result in *Laterodetrusion* (lateral and downward movement of the working condyle from its centric relation position), while a shallower angle would lead to a *Laterosurtrusion* (lateral and upward movement).

From the horizontal view, the effect of the **posterior wall** of the fossa can be seen.

The steeper the angle of the posterior wall, the more distal is the lingual groove of the lower molar and the more mesial would be the buccal groove of the upper molar (The working groove). (fig 11)

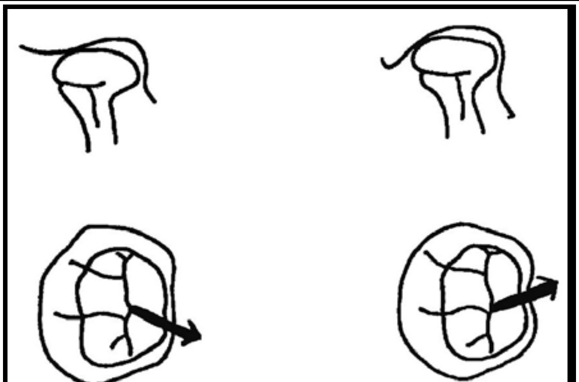


Fig.11:

The steeper angle of the posterior wall would lead to *Lateroprotrusion* (lateral and forward movement of the working condyle), while a shallower angle would result in *Lateroretrusion* (lateral and backward movement).

C-Orbiting Condyle (Non-Working Movement)

On the non-working side, the condyle moves medially, downwards and forwards, on **the medial wall** of the glenoid fossa. The stamp buccal cusps of the lower molars move downwards, anteriorly and medially, passing through the oblique lingual non-working grooves of the upper molars without contact. The upper palatal stamp cusps should pass through the lower oblique non-working grooves, also without contact.(fig 12)

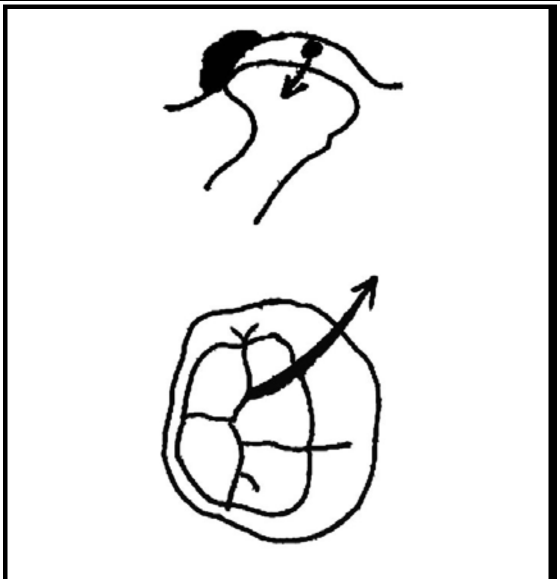


Fig.12:

The greater the descent or *Detrusion* of the orbiting condyle, the greater the angle of this movement the more would be the allowable cusp height, and the deeper the fossae.

Side Shift

This refers to the lateral bodily movement of the mandible in lateral excursion movements. This movement is a result of both rotation and translation of the condyles. If translation occurs nearer to the centric, an immediate side shift of the mandible occurs.

The greater the amount of immediate side shift, the lesser the cusp height and the shallower the fossae, the more distal the oblique groove is positioned in the upper, the more mesial in the lower. (fig 13)

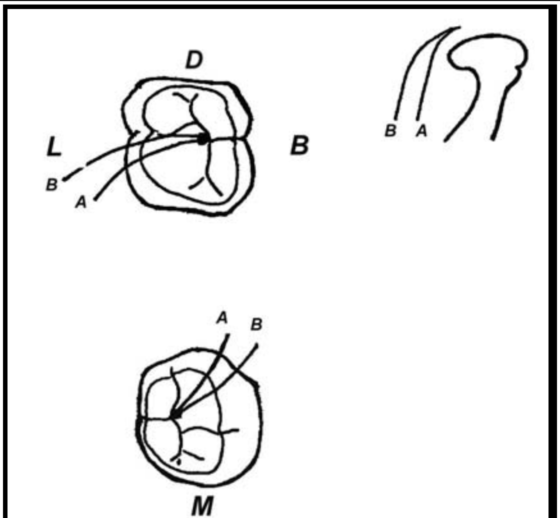


Fig.13:

D-Inter-Condylar Distance

This refers to the distance between the rotational centers of both condyles.

The *more* the inter-condylar distance, the more *distal* the grooves are in the *lower* molars, and the more *mesial* they are in the *upper* molars.

The *lesser* the inter-condylar distance, the more *mesial* the grooves are in the *lower* molars, and the more *distal* they are in the *upper* molars. (fig 14)

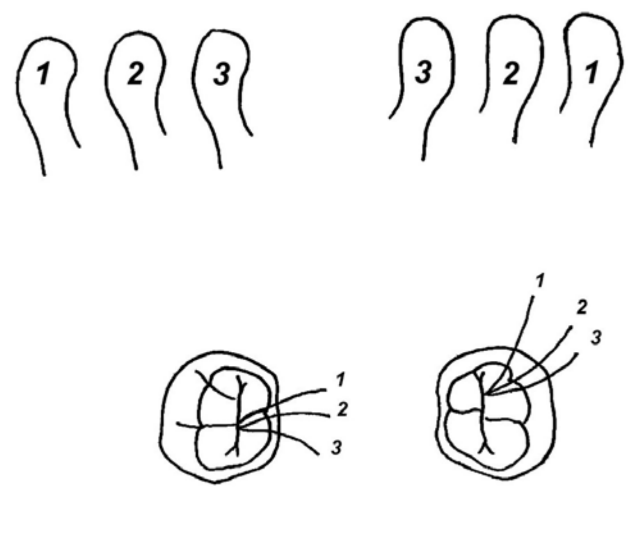


Fig.14:

2-The Anterior Determinants of Occlusion:

The effect of occlusion on mandibular movements and tooth morphology

These are the factors found within the dentition that are capable of affecting the mandibular movements.

1-Occlusal Plane

The more the plane of occlusion diverges from the path of the nonworking condyle, the greater is the allowable cusp height. The more parallel they are the shorter the cusps. (fig 15)

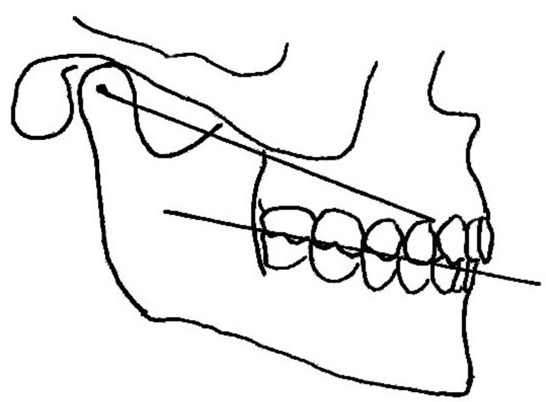


Fig.15:

2-Curve of Spee

The effect of the curve of Spee differs from each tooth to another. The effect depends on the plane of each individual tooth in the curve as it is compared to the path of the non-working condyle. The more they diverge from each other, the greater the allowable cusp height.(fig 16)

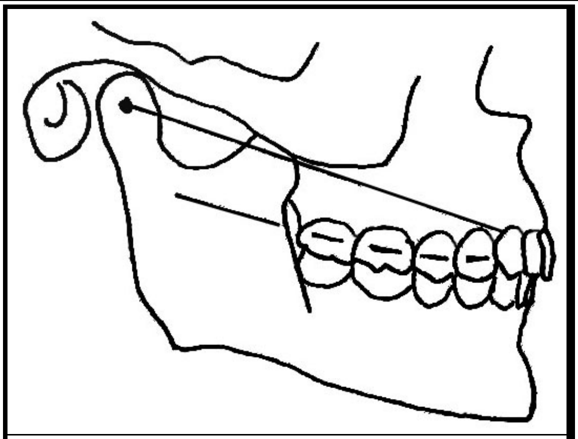


Fig.16:

3-Facial Position of the Teeth

The more laterally the teeth are positioned in reference to the midline, the more distally the grooves are in the maxillary teeth and the more mesially in the mandibular teeth.

The more anteriorly the teeth are positioned in reference to the to the rotational centers, the more distally the grooves are in the maxillary teeth and the more mesially in the mandibular teeth.

4-Vertical and Horizontal Overlap of the Anterior Teeth

The greater the vertical overlap, the greater is the allowable cusp height of the posterior teeth, while the greater the horizontal overlap of the anteriors, the shorter is the allowable cusp height of the posteriors. (fig 17)

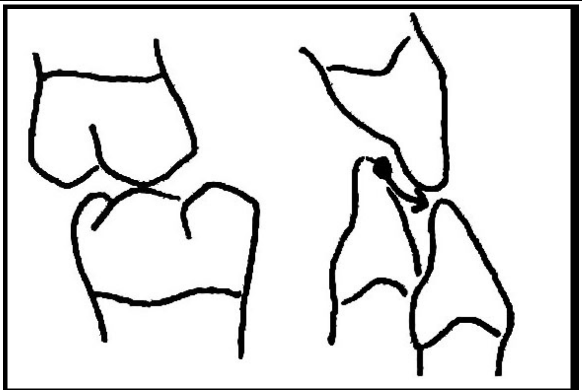


Fig.17:

Occlusion of Teeth

Teeth are so arranged in our jaws such that forces of mastication would be transmitted along their long axes. In addition the anterior teeth show a state of overlap in which the mandibular arch is contained within the maxillary arch.

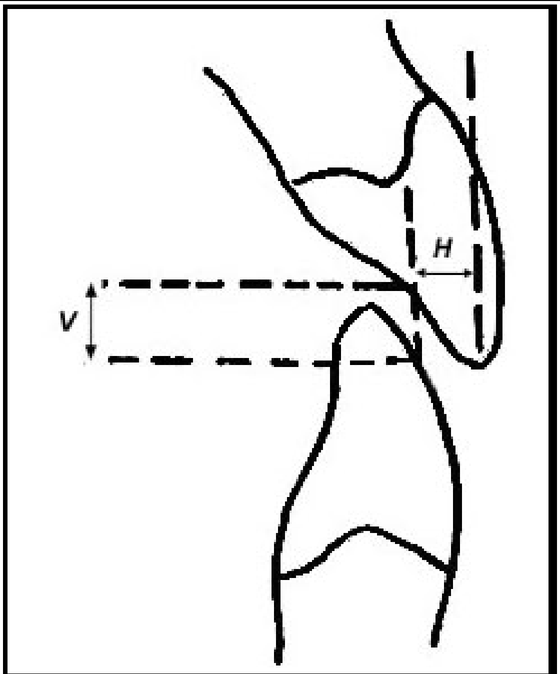


Fig.18:

This overlap may be either an ***Overbite*** (vertical overlap of the maxillary incisors over the mandibular incisors), or an ***Overjet*** (horizontal overlap of the maxillary incisors over the mandibular incisors). (fig 18)

Incisal Guidance:

The incisal guidance is defined as the inclination of the lingual surfaces of the upper six anterior teeth. Both the horizontal and vertical Overjet and Overlap influence it.

The incisal guidance is the predominating factor on occlusion, when compared to the condylar guidance. This is due to the fact that the incisal control is in a closer proximity to occlusion, and that it is made of hard non-resilient tooth structure as opposed to the condylar controls that contain compressible elements.

The inclined planes of the posterior teeth must be in full co-ordination with the incisal guidance.

Posselt's Envelope of Motion

Posselt described the influence of tooth contact on mandibular movements. He traced a point on the incisal edge of a mandibular incisor. By this tracing, he came up with what is called *"Posselt's envelope of motion"*.

The upper extent of this envelope is a product of tooth contact, while the movements of the mandible along all other borders of the envelope and movements within it are without tooth contact, and are controlled by the cranio-mandibular articulation (TMJ), and the muscles of mastication. (fig 19)

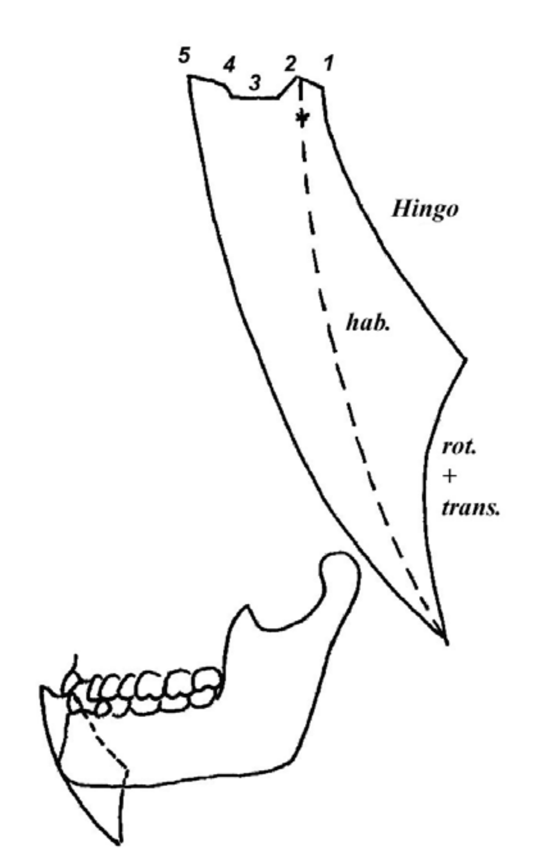


Fig.19:

Occlusal Contacts:

-*Types of Cusps*

From a coronal or frontal view of a section of the post canine teeth, the lingual cusps of the upper teeth stamp into the fossae of the lower teeth and the buccal cusps of the lower teeth stamp into the fossae of the upper teeth. The lingual cusps of the upper teeth and the buccal cusps of the lower teeth are therefore called ***Stamp Cusps***.

The buccal cusps of the upper teeth and the lingual cusps of the lower are called the ***Shear Cusps,*** which is because they pass closely by the stamp cusps on their way to occlusion to shear the food.

A stamp cusp constitutes about 60% of the bucco-lingual dimension of a molar, while the shear cusp constitutes the remaining 40%.(fig 20)

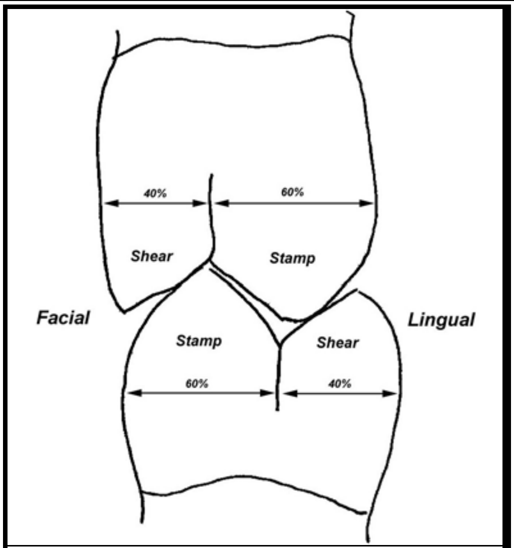


Fig.20:

-A , B , C Contacts

From the Frontal view, we will find a contact between the upper shearing buccal cusps and the lower buccal stamp cusps. This contact is called an ***A*** contact. Any contact between the buccal cusps of the post canine teeth is an ***A*** contact.

The contact between the lingual stamp cusp of the upper and the buccal stamp cusp of the lower is called a ***B*** contact. In other words, the common contact between the stamp cusps is a ***B*** contact.

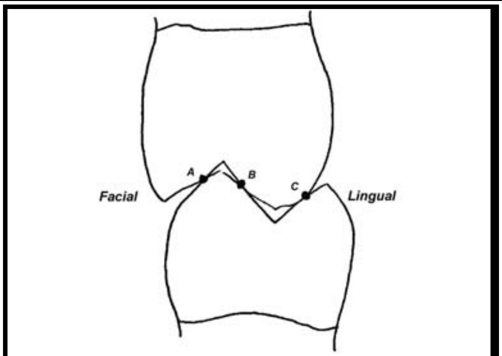


Fig.21:

A third contact exists between the upper lingual stamp cusp and the lower lingual shear cusp. This is called a ***C*** contact. Any contact between the lingual cusps of the post canine teeth is a ***C*** contact.

If we obtain an **A** and a **B** contacts in centric occlusion without the **C**, or if we obtain a **B** contact with a **C** contact without the **A**, we will still have good stability. This is because the closure forces will still be within the perimeter and in the long axis of the teeth. However, if we obtain an **A** and a **C** contacts without the **B** in centric, the parallelogram of force will be toward the buccal of the upper and the lingual of the lower. In other words, if the **B** contact is not obtained, we will have a case of malocclusion, or an unstable centric.(fig 21)

The B contacts are the most difficult to obtain and the most difficult to maintain and without them we have malocclusion.

- Closure Stoppers and Equalizers: (fig 22)

By looking from the Sagittal view, we will notice that the closure of the mandible does not occur in a straight upward movement but rather in a curve.

As the lower teeth come in contact with the upper teeth, contacts occur between mesial inclines of lower teeth and distal inclines of uppers. These contacts are called: Closure Stoppers. This is actually what they do: they stop the closure of the mandible.

At the same time, simultaneously, the distal inclines of the lowers come in contact with the mesial inclines of the uppers. These contacts are known as the Equalizers. Their function is to equalize the stoppers so that torque would not be exerted on the teeth.

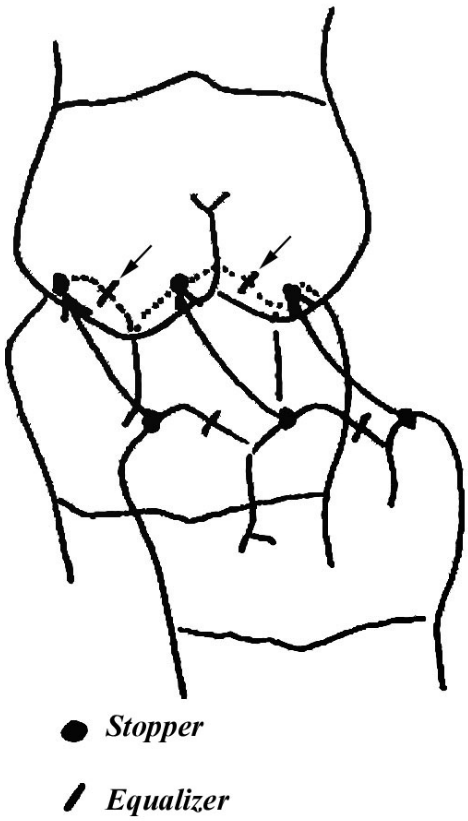


Fig.22:

If the closure of an Equalizer is simultaneous with the closure of the Closure Stopper, then the closure forces are equal and opposite. If the Equalizer contacts in closure before the Closure Stopper, the Equalizer becomes a deflector of the closure.

It is very important to the interdigitation of the occlusion to have simultaneous contacts between the Equalizers and Closure Stoppers in Centric Occlusion.

From a Horizontal view (fig 23), the closure stoppers, equalizers, A, B, and C contacts are so arranged in centric occlusion in such a way that they form pinpoint simultaneous contacts, in **Tripods** of three points of contacts in each fossa. These tripods of interocclusal contacts are immediately separated or discluded in any eccentric movements. Upon protrusive, right or left lateral movements, the centric contacts are immediately discluded into the depressions or grooves.

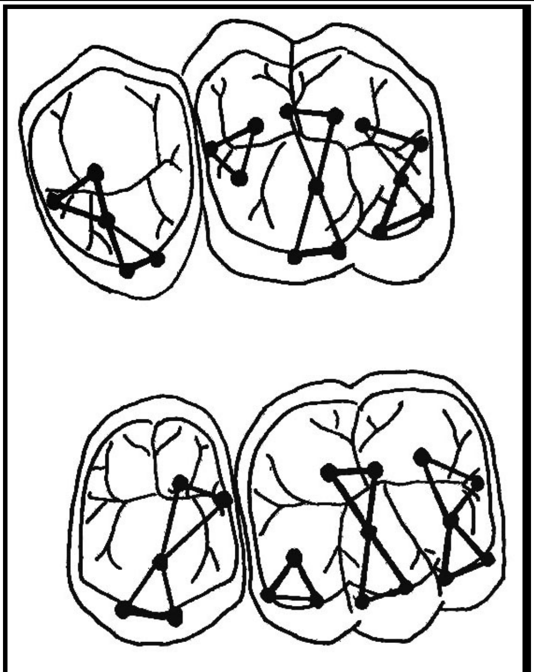


Fig.23:

THE UNIT OF OCCLUSION

The unit of occlusion is a cusp in a fossa. This cusp has in its fossa a working groove through which it moves in a working movement. It also has an idling or nonworking groove through which it idles in a non-working movement when the opposite side is working. It also posses an idling protrusive groove, through which it passes through during the protrusive movement.(fig 24)

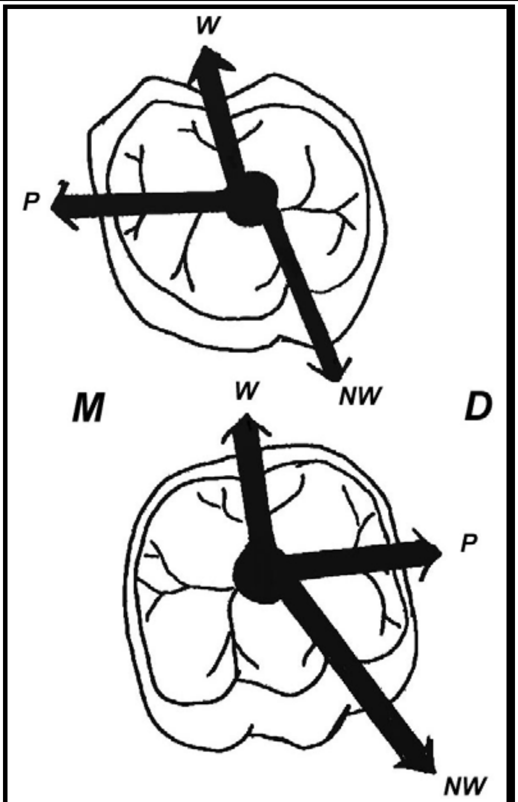


Fig.24:

These grooves serve as pathways in the fossae for their cusps to move freely and disclude in any eccentric movements.

The cusp in a fossa must have interocclusal contact: closure stoppers and equalizers in the sagittal plane, it must also have an A, B and a C interocclusal contacts in the frontal plane. Looking on this contact from the horizontal plane a resultant three-point contact between the cusp and fossa should exist. This is what we call Tripodization of a cusp in a fossa; it supplies occlusion stability mesio-distally as well as bucco-lingually.

"A TRIPODE IS THE MOST STABLE SYSTEM IN MECHANICS"

Static Occlusion

Types of Occlusion Relationship:

1-Cusp - Ridge Pattern of Occlusion:

The relation between the upper and lower teeth is such that one stamp cusp fits in a fossa and another stamp cusp of the same tooth fits into the embrasure area of two of the opposing teeth. This cusp-ridge arrangement is called a "tooth-to-two-teeth" occlusion, or a "cusp-embrasure" occlusal pattern.(fig 25)

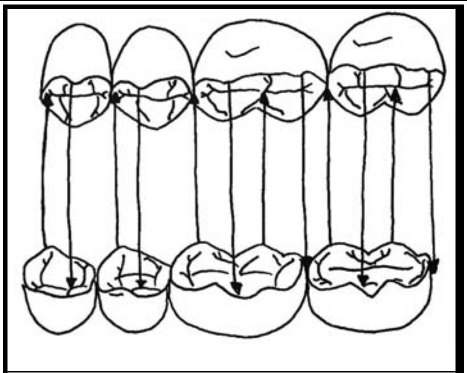


Fig.25:

2-Cusp-Fossa Pattern of Occlusion:

In this pattern, most or all of the stamp cusps fit into fossae. The "cusp -fossa" relationship normally produces an interdigitive relation of the cusps and fossae of one tooth with the cusps and fossae of only one opposing tooth. This pattern may also be called "tooth -to-one-tooth" occlusion.(fig 26)

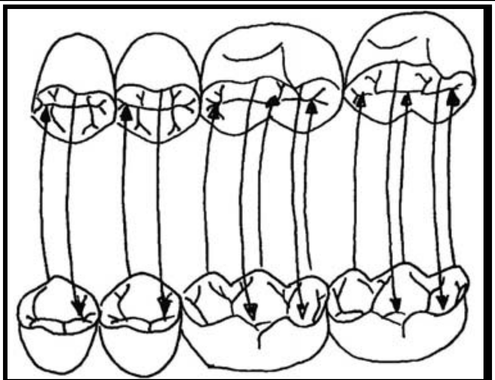


Fig.26:

Advantages of Cusp-Fossa over Cusp-Marginal Ridge Pattern of occlusion:

A cusp fossa relationship produces an interlocking of the upper and lower teeth, thus giving maximum support in centric occlusion. The forces are closer to the long axis of each tooth, giving a more efficient chewing apparatus. The occlusal forces are along the long axes of teeth: less tipping. There is elimination of food impaction between marginal ridges. The teeth are more stable, with more stable occlusion. Because the cusps make their contact with their ridges, not their tips, there is lesser wear of the cusp tips.

Dynamic Occlusion

Concepts of Occlusion:

1-Bilateral Balanced (5% of population)

Balanced occlusion is characterized by having all teeth in contact both in centric occlusion and during all eccentric mandibular movements. Since it has simultaneous tooth contacts during eccentric movements, all the teeth along with the TMJ share the lateral occlusal forces generated during these movements.

This theory was built on the basis that the forces generated are all horizontal rather than vertical. Since these lateral forces are harmful to the periodontium, and in order to reduce the lateral pressure, these forces need to be distributed as widely as possible to limit their harmful effect.

In order to produce a full balance, it is sometimes necessary to increase the vertical dimension to an intolerable limit.

This technique is both difficult to fabricate and to maintain.

To summarize:

-All teeth contact each other during centric and all eccentric movement.

-There is cross mouth and cross tooth contacts.

-It is not a healthy occlusion.

-Does not normally occur.

-Complete dentures are made with this type of occlusion for the purpose of stability.

2-Unilateral Balanced: (Group Function)(20-25%)

This type of occlusion is seen when all the facial ridges of teeth on the working side contact their opposers, while those on the nonworking side do not.

This concept is characterized by:

1-Applying the theory of Long Centric.

2-All working side teeth share lateral forces during lateral movements

3-Nonworking side teeth are free from contacts during lateral movements

It was felt that all working side teeth should share and bear the lateral pressures during lateral movements by eliminating the nonworking contacts. However, the pressure differences in molars as compared to anterior teeth were not thought of. The lateral pressure on

a canine is approximately one-eighth that on a second molar. By that, a molar would bear a much greater burden than a canine, and as such, all teeth would not be sharing the same amount of load.

To summarize:

-On the working side: canine and post canine teeth are in contact with their opposers.

-On the nonworking side: no contacts exist between teeth.

-This type of occlusion is found naturally, and may cause wear and mobility.

Long Centric:

Long centric or “Freedom in Centric” is an occlusal concept, in which a flat region is built between the retruded position and the maximum intercuspation, without a change in the vertical dimension. This flat region, having a length of 0.5-1mm, gives the mandible freedom to close in Centric or slightly anterior to it without any interference.

Schuyler first introduced this concept in the 1930’s. According to him the reasons for such a line of treatment were:

1-The fit of the condyle into the disc is not like the fit of a mechanical ball into its bearing, in other words, there is some front to back movement within the boundaries of the disc.

2-There is a difference that exists between a firm and a light closure. In a firm closure there is strong contraction of the elevator muscles pulling the condyles to the back of the disc. In a light closure, there is insufficient pull by the muscles to completely place the condyle at the back of the disc. These leads to a situation were there is a difference between the firm and light terminal hinge closures.

3-There is a difference in closure according to the patient's posture.

Cases that need Freedom in Centric:

-When teeth are in the way if the patients close normally, but are fine when the mandible is pushed to the back.

-When teeth are fine when laying down, but are in the way while sitting upright.

If a patient needs long centric and does not get it, the lower incisors will strike the lingual inclines of the upper incisors causing instability, followed by bruxism and clenching.

3-Cuspid Protected: (Mutually Protected)(60-70%)

This type of occlusion occurs when the posterior teeth protect the anterior teeth in centric position. The centric stops on the posterior teeth also prevent excess loading to be transferred to the TMJ.

The anterior teeth protect the canine and the posterior teeth during the protrusive movement, while the canine protects the incisors and posterior teeth during lateral movements.

D'Amico advocated the Canine guided occlusion in 1958, after performing studies on the canines in animals and humans.

He considered the canine as being the key of occlusion.

This was based on the facts that:

1-The canine has a good, if not superb, crown-root ratio.

2-The presence of the canine eminence formed of hard compact bone surrounding the tooth.

3-The location of the canine being far from the TMJ, thus receiving less stress.

4-The canine has many receptors in the periodontium.

To summarize:

-Posterior teeth are in contact in the centric position.

-Anterior teeth guide the mandible in the protrusive movement.

-Canines guide the mandible in the lateral movements.

-Posterior teeth are separated and are **not** in contact in all eccentric movements.

Organic Occlusion:

This is a therapeutic type occlusion that was introduced by Stuart and Stallard in 1972, as an approach for treatment in full mouth reconstructions.

Stuart and Stallard studied patients over 60 years of age, without attrition and studied their occlusion.

It was observed that molars did not contact during eccentric movements but only in maximum intercuspation, while the anterior teeth had no contacts. The molars were responsible for bearing the vertical occlusal loads. It was concluded that anterior teeth protect the posterior teeth and the posterior teeth protect the anteriors.

The criteria set forth were: Cuspid protected occlusion.

1- Cusp-Fossa relation

2- Simultaneous contact of posterior teeth in centric.

3- Anterior teeth are in contact in the protrusive movement.

4- Tripoding of the stamp cusps as they occlude in their opposing fossae.

Occlusal Adjustments

Occlusal adjustment refers to selective recontouring and grinding of teeth in order to remove prematurities.

Indications:

1-Evidence of trauma from occlusion, by changes in the periodontium
2-Symptoms of TMJ dysfunction and habit neurosis (Bruxism)
3-Excessive tooth mobility
4-Excessive tooth wear
5-Need for extensive restorative work
6-Prerestorative treatment

Occlusal adjustments aim in allowing maximal intercuspation of teeth in centric relation, by removing centric prematurities, in addition to removing any eccentric interferences.

By such a procedure, the adaptive arc of closure is replaced by the skeletal arc, and the patient is allowed to close in centric relation without deflective occlusal contacts.

In other words, the patient's occlusion is adjusted in such a manner so that his habitual closure would coincide with his centric closure.

Occlusal adjustments are made by selective reshaping or grinding of ridges of cusps. These changes are made in marginal ridge angles, cusp heights, and angles of triangle and oblique ridges.

It is very important in the process of occlusal adjustments to maintain the rounded contours and not to create flat surfaces.

Aim of Adjustment:

Our aim is to develop maximal intercuspation of teeth in the centric relation. The post canine teeth should only contact in centric, while the anterior teeth carry all eccentric contacts. This procedure follows the criteria set forth in "Organic Occlusion".

Sequence of Occlusal Adjustment

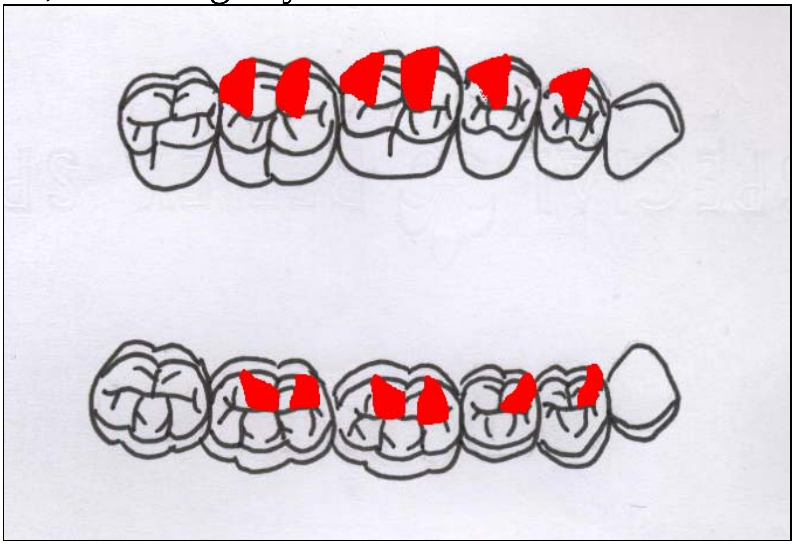
Adjustments should be made first by correcting the eccentric relations then correcting the centric. By such a sequence, once the centric contacts have been established, there will be no need for further corrections. It is imperative that once the centric is established, teeth should never be taken out of centric relation occlusion.

A-Correction of Protrusive Interferences:

The patient is asked to move his teeth into an edge-to-edge incisal relation.

Existence of contacts in the premolars or molars in such a protrusive movement is considered as a protrusive prematurity that needs correction.

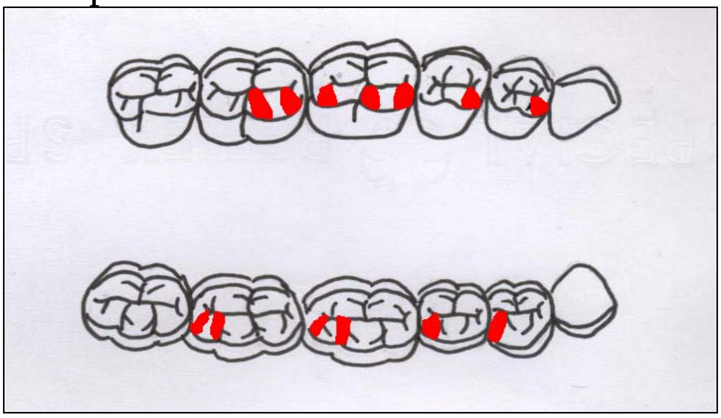
Tooth structure is removed from the distal inclines of the buccal cusps of maxillary and the mesial inclines of the lingual cusps of mandibular teeth. After removal of these interferences, the mandible is moved distally from the edge-to-edge position toward the centric position, removing any contacts that are seen till reaching the centric.



B-Correction of Non-Working Interferences:

The mandible is moved to the position where the canines at an edge-to-edge relation on the working side. Existence of contacts on the opposite side (non-working) side in such a movement is considered as a non-working side prematurity that needs correction.

Depending on where the interferences are, either oblique grooves directed mesially are made in the maxillary teeth to act as pathways for the mandibular buccal cusps, or oblique grooves directed distally are made in the mandibular teeth serving as pathways for the maxillary palatal cusps.



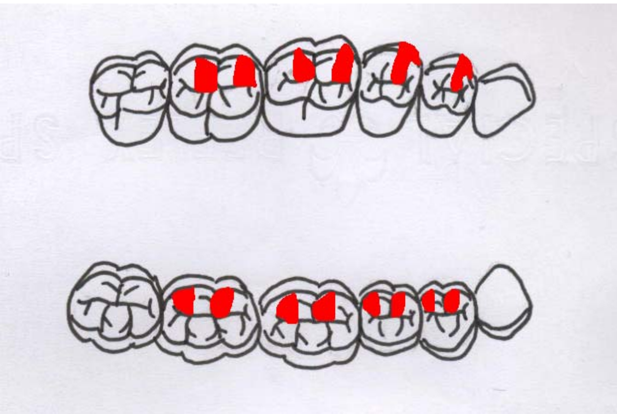
C-Correction of Working Interferences:

The mandible is moved again to the position of edge-to-edge of the canines on the working side. Existence of contacts of premolars or molars on that side at that position is considered as a working side prematurity.

Reduction in tooth structure at the expense of the mesial inclines of the maxillary buccal cusps and the distal inclines of the mandibular lingual cusps is made to eliminate the working side interferences.

Following the correction at the edge-to-edge position, successive stations are tested nearer and nearer to the centric position, eliminating any interference in the posterior teeth till the centric position is reached.

After correcting and removing the non-working and working interferences on one side, the same procedure is repeated for the other side.



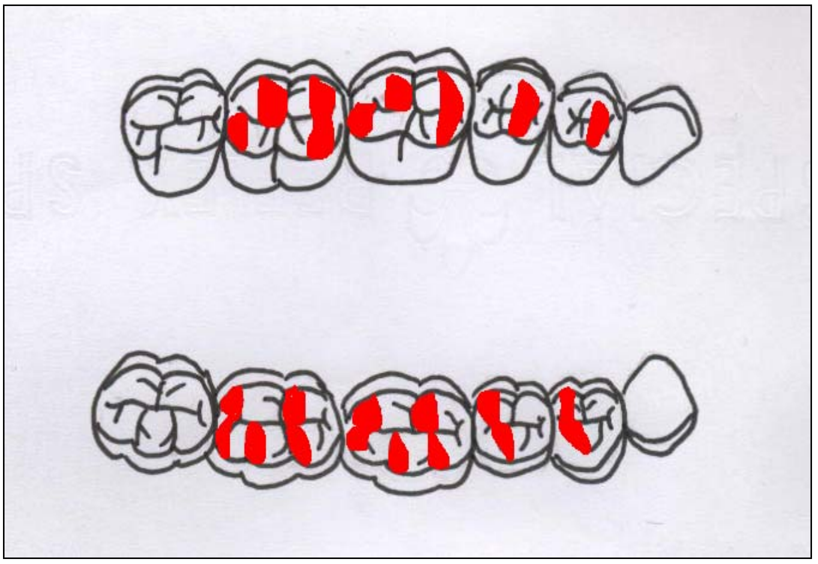
D-Correction of Centric Relation Occlusal Interferences:

This step is started only when all eccentric interferences have been corrected.

The mandible is guided to close in centric relation till the initial tooth contact occurs. If after the initial contact, the mandible is deflected and continues to close, then a centric prematurity exists that needs correction.

Corrections are made in the mesial slopes of maxillary teeth and distal slopes of mandibular teeth. These are carried out till the deflection or slide from the initial tooth contact in centric has been eliminated.

The final step after completion of adjustments is to deepen the fossae in order to attain a more closed centric related closure.



Articulators In Fixed Prosthodontics

Introduction:

Ever since man was able to make impressions of teeth and pour them into positive molds, he has been seeking ways to instrumentate these casts.

With the understanding of the complexities of the masticatory system and the impracticality of performing prosthetics directly on the patient, the profession has sought instrumentation and recording devices to simulate the system and therefore fabricate the prosthesis outside the mouth. This transferring vehicle seems to be the essence of articulation and the development of recording devices and articulators.

Definition

An Articulator is a mechanical instrument capable of maintaining opposing casts in their correct interocclusal relationship while allowing certain mandibular movements to be simulated. This device acts as the patient in his absence.
The number of achievable mandibular movements and the accuracy of reproduction are used to classify different types of articulators.

Uses of An Articulator:

Diagnostic

Since unmounted casts can only give information as to the alignment of individual arches, but can not permit analysis of functional relationships, the diagnostic casts need to be attached to an articulator. In other words, to properly evaluate a patient s occlusion, and along with other tools for diagnosis, it is mandatory that diagnostic casts be placed on an articulator in approximately the same relationship to the tempromandibular joints as exists in the patient.

Occlusal Equilibration

Prior to intervening in a patient s occlusion by adjustments for equilibration, a thorough study of tooth contacts in the mouth and on the diagnostic casts that are mounted on an adjustable articulator should be made to determine whether occlusal refinement would be beneficial. Adjustments should be made on the mounted casts that are in the centric relation position prior to making the changes in the mouthThis diagnostic equilibration provides valuable information by revealing the extent of reduction needed to establish the desired relation. For doing so, the casts should first be colored by a water-based poster paint, so that after alterations on the casts, these corrections would be evident by the absence of the colored surface.

Another use related to occlusal problems and disharmonies is the fabrication of occlusal splints.

Working

In fabrication of any of the fixed restorations and/ or prostheses, working casts are mounted on an articulator using the records taken from the patient. By this

procedure, it is possible to fabricate restorations that occlude and function properly. The wax patterns are made on the mounted casts, and adjusted to both proper occlusion and esthetics, and later on upon completion, they are checked and adjusted on the articulator prior to insertion in the mouth.

Types of Articulators

1-Non-Adjustable Articulators:

Simple Hinge: (Fig. 1)

Also known as the plain line or the straight line articulator. These types of articulators possess the ability to produce opening and closing movements. The centric occlusion and/or maximum intercuspation can be accurately recorded and maintained, however no information regarding the eccentric movements of protrusive, working and nonworking positions is available. These positions and movements can not be duplicated on these instruments.

Fig. 1 Simple hinge articulator

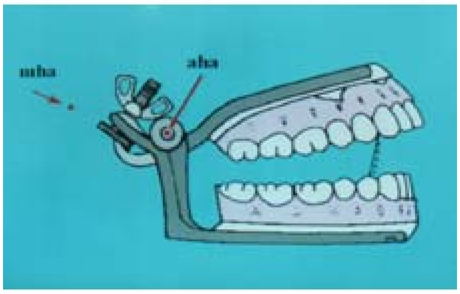
Fixed Condylar guidance controls: (Fig. 2)

These articulators can permit some eccentric movements. They are limited in the direction and form and can not be altered to accommodate individual patient

Fig. 2 Fixed condylar guidance control articulators

variations.

In this category of articulators, another disadvantage exists, which is the size of the instrument. These articulators being small in size, their condyles are closer together than the condyles are in the skull. In addition, the centers of rotation of these articulators are closer to the casts than the joints would be to the arches. This would present the problem that the movements do not follow the actual intraoral pathways. This disadvantage would result in a state where the lower member would close at a steeper arc, than the actual closing arc existing in the mouth. This in return would make a finished restoration exhibit a centric prematurity, at the mesial inclines of upper teeth and the distal inclines of the lower, resulting in the deflection or slide of the mandible upon closure. (Fig. 3)



At the same time, because the intercondylar distance is by far smaller than that in the skull, a finished restoration fabricated on such an articulator would have a non working side interference.

2-Semi-Adjustable Articulators:

These articulators are anatomically nearly normal in size and design. They can be adjusted to individually different mandibular movements.

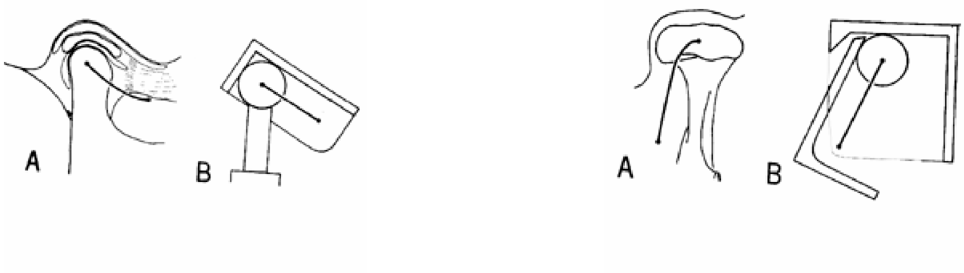


Fig. 4. Semi-adjustable articulators record the starting and ending points of the movement, while the actual character is duplicated with an average path.

Although they are more accurate than non-adjustable articulators, as they are more normally sized, and capable of duplicating eccentric movements, they still possess the disadvantage of being arbitrary. This is due to the fact that the clinical information used to set these instruments is recorded only at the starting and ending points of the movements, while the character of the actual movement is duplicated on the articulator with an average path. (Fig. 4)

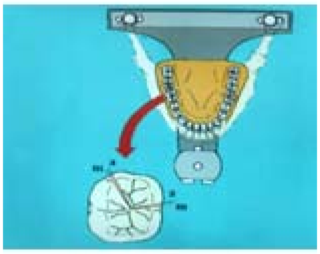
Another reason is that the upper casts are usually mounted to the upper element of the articulator with a face bow that uses an arbitrary hinge axis.

It should be clear that the semiadjustable articulators are capable of approximately following the mandibular movements, however this capability by no means should be considered accurate. Nevertheless, the amount of accuracy is much greater than would be expected from a non-adjustable articulator.

Finished restorations fabricated on these instruments need less intraoral adjustments. The adjustments might be needed especially in eccentric movements.

With the Semi-Adjustable articulators being close to being normal in size, both the arc of closure and the intercondylar distance of the lower member are very close to that found in the skull. This would in return minimize the adjustments that would be needed in a restoration upon insertion in the mouth. (Fig. 5a, b)

Two designs of Semi-adjustable articulators are available, namely Arcon and



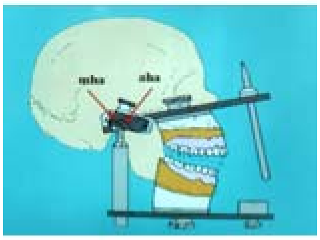


Fig. 5 a & b
Both the distance from the cast to the rotational axis of the articulator and the inter condylar distance are close to those in the skull.

NonArcon. The word Arcon is derived from the first halves of the words: Articulator and Condyle. The Arcon articulator would thus refer to an anatomically correct design, while the NonArcon refers to an anatomically incorrect designed articulator.

Non-Arcon Articulators:

(Example: Hanau H2 Articulator)
(Fig. 6)

Fig.6 Hanau Articulator

The NonArcon articulators have their condyles attached to the upper member, while their condylar controls are attached to the lower member.

These articulators are available only with a straight condylar guidance pathway. This would only allow the condyles to move in a straight line during eccentric movements. In addition, the Bennett movement or side shift can only be reproduced in a straight progressive form, with no provision for the immediate shift.

The Hanau H2 articulator, an example for the Non-Arcon articulators has a fixed intercondylar distance of 110 mm.

It can accept a facebow transfer, relating the maxillary cast to the rotational centers of the articulator. The lateral horizontal condylar inclinations are simulated by means of a protrusive interocclusal record. The amount of side shift is calculated from the lateral horizontal condylar inclination and the vertical condylar posts are rotated accordingly.

One point to be noted is that both the upper and lower members are mechanically attached to each other by means of the condyles and their guidances.

Arcon Articulators:

(Example: Whip Mix Articulator)
(Fig. 7)

Fig. 7 Whip Mix Articulator

An Arcon articulator refers to that category of semi-adjustable articulators in which the design is anatomically normal. The condyles are attached to the lower member, while the condylar control is attached to the upper member.

These articulators are available in two different models, with the condylar guidance having either a straight or a curved pathway. Having this advantage of using a curved pathway for the condyles, although still arbitrary, would make the movements of the condyles more close to normal, than would the straight line pathway. The curvature of the superior wall has a fixed curvature equivalent to a circle with a 0.75-inch radius, while the medial surface forms a fixed angle of 7 degrees with the midsagittal plane of the skull. The intercondylar distance is adjustable to three different sizes: small (96mm), medium (110mm), and large (124mm).

A facebow is used to mount the upper cast. The horizontal condylar inclinations are set by means of lateral and protrusive interocclusal records. The amount of side shift is set by means of lateral interocclusal record.

The upper and lower members are mechanically attached by means of a spring latch assembly, and can be separated from each other during operation.
The Arcon articulators are capable of reproducing both the immediate and the progressive side shifts.

These articulators also have the capability of accepting a terminal hinge axis transfer, made with a mandibular facebow. This would make the use of articulator more accurate as it would be possible to mount the upper casts at a relation with the actual hinge axis of the patient.

Records needed for mounting on a Semi-adjustable Articulator:

I-Face Bow record:

The face bow record is basically used to mount the upper cast to the articulator. In order to correctly mount these casts on the articulator, they should be placed at the same relation that the teeth have to the rotational centers of the condyles.
In order to do so, a face bow is used to capture that relation.

There are two types of facebows: the hinge axis facebow and the average hinge axis facebow.

a-The Hinge axis facebow: (Kinematic Facebow) (Fig. 8)

Fig. 8 Hinge Axis Facebow

This is used both to locate the actual hinge axis of a patient, using a mandibular clutch fixed to the lower arch of the patient (referred to then, as a mandibular facebow), and in relating the upper arch to the actual hinge axis of the skull, previously located by the mandibular facebow. Upon mounting the upper casts with this record, the actual relation between the maxilla and the terminal hinge axis is transferred accurately to the articulator.

b-The Average-Axis Facebow: (Fig. 9)

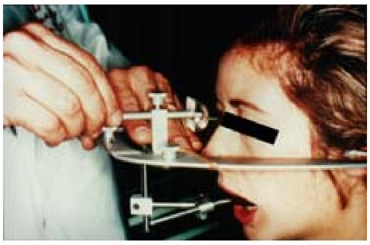


Fig. 9 Average Axis Facebow

This face bow utilizes two posterior points as being the average points of the hinge axis. The average points differ from one brand of articulator to another, so does the third point of reference (the anterior point of reference).
In the case of the Hanau articulator the posterior reference points are points that are 13 mm away from the Tragus of the ear along the Tragus-Eye line, while the third, anterior point of reference coincides with the lowermost point on the bony rim of the orbit. While in the case of the Whip Mix articulator, the two posterior reference points are the two external auditory meatuses, while the anterior reference point is the Nasion.

II-Centric relation record:

This record is used to relate the lower cast to the previously mounted upper cast. When coming to mount the lower cast to the upper that has already been mounted, either a maximum intercuspation or a centric relation record should be made to relate the lower cast to the upper on the articulator.

For mounting the mandibular cast in the maximum intercuspal position (Fig.10) both casts are held together in their interdigitative position and secured using sticky wax while mounting of the lower cast is accomplished. This would require that there would be sufficie ation of the casts together.

Fig. 10 Casts held in Maximum intercuspation position.

In addition, this record may be made using a variety of materials, among which are Wax, Polyvinyl Siloxane impression materials, Zinc Oxide and Eugenol registration materials, and Auto-Polymerizing resin. For taking this record, the patient is instructed to hold his teeth tightly in contact while the registration material sets.

On the other hand for mour sition (Fig. 11), a recording material is be placed between t ble guided in the closing movement until the teeth contac ming in contact with their opposing teeth. By this, the centr away from the influence of

centric prematurities that would deflect the mandible and slide it to close in the maximum intercuspal position.

A simple procedure would be using Wax wafers, Puttylike elastomeric materials, and auto polymerizing material relined with Zinc Oxide-Eugenol. These materials are formed to fit the teeth and the patient is instructed to close his mandible on the material and hold his mandible motionless just prior to any tooth contact, till the material hardens.

A well accepted technique for doing this utilizes an anterior Jig (also known as Lucia jig, or anterior deprogrammer) that holds the teeth slightly out of contact while using an impression material to record the relation of the mandibular to the maxillary teeth. (Fig. 12)

This record is used when it is needed to fabricate restorations to occlude properly when the mandible is in its terminal hinge position. By this, it would be

Fig.12 Anterior Jig used for Centric relation registration

possible to fabricate restorations that do not posses any centric prematurities.

III-Eccentric relation records

These records are made to adjust the reading in the articulator for the condylar control angle and the amount of side shift.

a-Protrusive Record:

This record can be made using wax, by guiding the mandible forward until the lower anterior teeth are even with or just beyond the incisal edges of the maxillary incisors. (Fig. 13) The mandible is then guided to close till the teeth indent the wax. It is imperative that teeth should not penetrate the wax to the extent that upper and lower teeth would get into contact. Such a contact would cause rocking of the mandible and this record would be faulty.

Fig. 13.Guiding the mandible for the protrusive record

The protrusive record is used to adjust the condylar control angles on both the

right and left sides with one record.

b-Lateral Excursion Records:

The lateral excursion records can also be made using wax. (Fig. 14) The mandible is guided into both right and left working movements, and the record in taken with the mandibular teeth just beyond the edge-to-edge relationship, and the patient is instructed to close the jaw at that position just enough to create shallow cusp tip and incisal edge indentations.

This record is needed for an articulator such as the Arcon Whip-Mix Semi-

Fig. 14 guiding the mandible for a lateral excursion record

adjustable articulator, and is used to adjust the condylar control angle and the side shift on the opposite side of the movement. A right excursion record would be used to adjust the left control, while a left record would be used in adjusting the right control.

As noted, the condylar control angle is adjusted using two records: the protrusive and the lateral excursive records. In the event that the two records would give two different readings for the same condyle, the lower reading should be used for that condyle. Another way of dealing with this situation is to adjust the control for each movement separately by changing the angle each time upon performing that movement on the articulator.

The Non-Arcon Hanau semi-adjustable articulator on the other hand, and because it is not capable of accepting lateral jaw relation records, utilizes the protrusive record through the Hanau equation: [L = H/8 +12] to calculate the lateral condylar settings.

Advantages of Arcon over Non-Arcon Semi-Adjustable Articulators

The main advantage lies in the fact that the relation between the maxillary cast and the axis orbital plane remains constant when the opposing casts are separated. (12)

When separation of the casts occurs in a Non-Arcon articulator, the relationship of the casts to the axis-orbital plane is lost and true interpretation of the relation of the occlusal plane to the horizontal is not possible. (Fig. 17)

This advantage is practically seen when mounting a lower cast to the maxillary

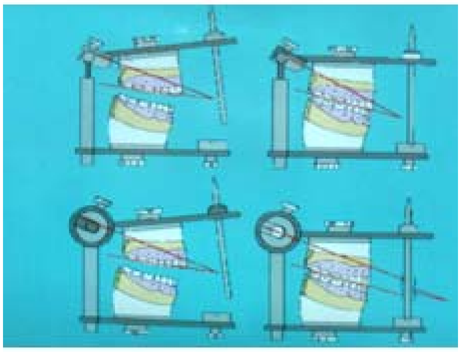


Fig. 17 The angle between the occlusal plane and the condylar angle remains the same when the articulator is opened in the Arcon articulator. This angle changes in a Non-Arcon Articulator.

cast using a centric relation record, where the registration material must have sufficient thickness so that the teeth would not come in contact. The cast is in such a case mounted in a raised vertical dimension than the working vertical dimension. After removal of the centric relation record and closing the articulator, the angle between the condylar pathway and the occlusal plane remains the same with an Arcon articulator.

On the other hand, this is not the case with the Non-Arcon articulators, where this angle is altered. A loss of about 8 degrees would be expected. This decreased angle in the inclination of the condylar control would affect the cusp height, fossa depth and angle of the cusp in the finished restoration.

It should be noted however that in registering the jaw relation for the construction of complete dentures, the centric relation record is taken at the working vertical dimension. This will in return lead to the stability of the angle between the

occlusal plane and the condylar inclination. By this understanding, it seems

acceptable to limit the use of a Non-Arcon articulator such as the Hanau articulator to denture construction

Another advantage for the Arcon articulators is their capability of accepting a terminal hinge axis transfer (Fig. 18). This would result in a more accurate relation of the maxillary cast to the rotational center of the condyles on the articulator when compared to the relation of the maxilla to the condyles in the patient.

Fig. 18 Transferring the hinge axis to a Whip Mix articulator.

Other advantages include the adjustable intercondyla condylar control available and the inherent capability of simula shift.

3-Fully Adjustable Articulator

Examples: Stuart, Denar
(Fig. 19)

Fig.19 Fully Adjustable Articulators

Description:

These instruments can provide the greatest amount of accuracy. They are capable of accurately reproducing all mandibular movements both in direction and form. The movements are recorded and reproduced on the articulator from the point of initiation to the point of termination, that is they are capable of reproducing the entire character of movements including that of the immediate and the progressive side shifts, the direction and inclination of condylar movements, and the intercondylar distance. The fully adjustable articulators can reproduce all mandibular movements so accurately that Stuart described it as a (Gnathological Computer). The word

Programming the articulator is used to denote adjusting the articulator to the individual readings of a patient, as if a computer was programmed.

These articulators are expensive, and the technique requires a great degree of skill and is time consuming.

Records needed for mounting on a Fully Adjustable Articulator:

a-Hinge axis location and Face bow record:

For working with the fully adjustable articulator, and for maximum accuracy, the face bow record has to be made in relation to the actual terminal hinge axis. This should first be located using a Kinematic face bow. The Hinge axis points should be marked and tattooed, to be used later on with the upper face bow for mounting the upper cast to the articulator. (Fig.8) and (Fig. 20 a,b)

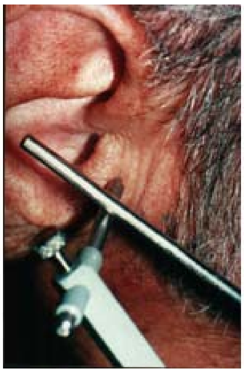


Fig.20 a, b Locating the actual hinge axis

b-Centric Relation Record:

Since the use of such an articulator would be limited to those cases that need full reconstruction and rehabilitation, is imperative that occlusion for such cases be restored in the centric relation.

Therefore, a centric relation record should be made using a deprogramming anterior device such as the Lucia Jig, while recording the centric relation.

For making the centric relation record, an anterior resin jig is used to hold the teeth slightly out of contact .It is formed around the maxillary central incisors and shaped so that it would form a ramp with an upward lingual slope.

By the use of malleable metal, shaped to conform to the arch, the centric relation is registered with Zinc Oxide-Eugenol registration paste. Other materials may also be used for that record, however the choice of the paste is for accuracy reasons. (Fig. 21)

Fig. 21.Centric relation record with the anterior jig and the malleable metal carrying the zinc oxide-eugenol paste.

c-Pantographic tracings:

The accurate registration of different jaw movements is needed to adjust the paths and directions that the articulator performs to accurately simulate those made in the mouth. For doing so, tracing the exact movements made by the mandible is needed to register the exact direction and path and amount of those movements.

A pantographic tracing is made by the use of the pantograph, to record lateral and protrusive excursions.

The pantograph (Fig. 22) consists of two facebows, one affixed to the maxilla while the other to the mandible, with the use of clutches that are attached to the teeth.

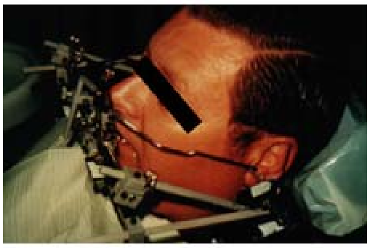


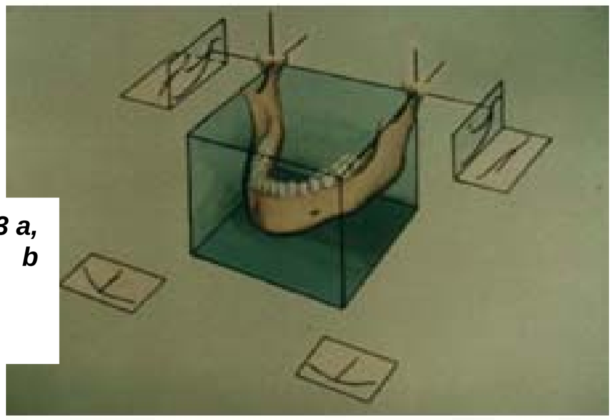
Fig. 22 The Pantograph

The tracings are made by styli attached to one member and small tables upon which the tracings are drawn attached to the other member, opposite the styli. There are posterior vertical and horizontal tables on both right and left sides, along with two anterior tables, one on each side. The patient is instructed to move his mandible through protrusive, right and left lateral excursion movements, while the styli scribe on their opposing tables the paths followed by the condyles in those movements.

The pantographic tracings (Fig. 23 a, b) are used to program the fully adjustable articulator.

When the pantograph is attached to the articulator, adjustments and alterations are made to the movements of the articulator follows the same paths that was scribed

Fig. 23 a, b



by the styli on their tables, that is following the paths of the condyles in their movements.

Computerized systems have also been developed. A print out is obtained and used to program the articulator. The computerized systems closely resembles the manual pantograph and are much more economical as regards time, as the transfer stage is eliminated.

d-Stereographs: (Fig. 24a,b)

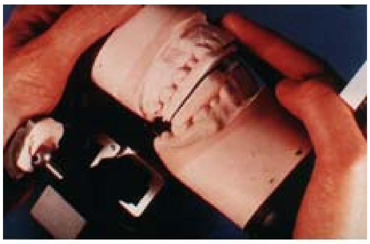


Fig.24 a, b. Stereograph in the mouth then programming the articulator

This is another method for programming the fully adjustable articulators. Clutches are made to fit the teeth, and the patient is instructed to perform lateral and protrusive excursions, during which, studs in one clutch cut into the opposing clutch.

For programming the articulator, the clutches are transferred to it, and it is moved to follow along the paths formed by the cut out areas. The condyles of the articulator are made to mold auto-polymerizing resin, previously placed in the articulator fossae. This enables the original jaw movements to be reproduced when the clutches are removed.

Requirements of an Articulator:

The requirements as stated by Winkler were described as the minimal requirements necessary for fabricating complete dentures to the patient s centric position and to a balanced occlusion. These were:

1. The articulator should be able to maintain centric position.
2. The casts should be easily both removed and attached to the articulator without loosing the horizontal and vertical relationships.
3. The articulator should have an incisal pin that is adjustable and calibrated. This would provide a positive control over the patient s vertical dimension by the operator.

4. The articulator should be able to open and close in a hinge like manner.
5. It should be able to accept a facebow record, with the use of an anterior third point of reference, for mounting of the upper cast. This would allow minor changes to be made in the vertical dimension without changes in the patients occlusion in centric position.
6. The material of its construction should be rigid, accurate and non-corrosive. The moving parts should resist wear.
7. The design should provide adequate distance between upper and lower members and that it provides adequate vision from the rear.
8. It should be stable on the laboratory bench, neither bulky nor heavy.
9. The condylar guides should allow right and left lateral and protrusive movements.
10. The condylar guides should be adjustable horizontally.
11. The incisal table should be adjustable mechanically, or can be customized either with resin or by grinding.

A more recent list for requirements of an articulator were listed by Hobo and Takayama [11], and were related to the purpose needed from an articulator.
According to both Hobo and Takayama, the purpose of an articulator is to establish centric relation and to reproduce mandibular eccentric movements.

In order to establish proper centric relation, an articulator must be equipped with a reliable centric latch.

The factors that influence the reproduction of eccentric movements are:

1. An articulator must have a straight sagittal condylar path.
2. It should reproduce either one of the sagittal protrusive or the nonworking side lateral condylar path inclinations, but does not necessarily reproduce Fisher s angle.
3. The immediate mandibular translation does not have to be reproduced.
4. Bennett angle should be fixed to 15 degrees.
5. The working side condylar path must translate straight outwards along the transverse horizontal axis.
6. An articulator does not need a curved anterior guide table.
7. The anterior guide table should be shaped like a triangular gutter and be adjustable for both sagittal and lateral wing angles.

Effectiveness of an Articulator

It can be concluded that the effectiveness of any articulator depends on:

1. How well the operator understands its purpose and its construction.
2. How enthusiastic he is for that particular instrument.
3. How well he understands the anatomy of the joints, their movements and the neuromuscular system.
4. How much precision and accuracy are used in registering jaw relations.
5. How sensitive the instrument is to these records.

There has always been that controversy as to which articulator would be considered the best. It must be clear that the person using the articulator is more important than the instrument itself. If a dentist does understand the instrument and its deficiencies, he can compensate for its inherent inadequacies.

It was Dawson s understanding that the simpler the articulating device, the more compensations must be made for its shortcomings, but if compensations can be made easily and accurately, there is practical value in keeping the instrumentation as simple as possible.

It is safe to conclude that an articulator is only as good as the person programming it.