

Biomechanics of the Cranio-Mandibular Complex



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Objectives:

- Review the types of mandibular movement that occur in the TMJ
 - Rotational
 - Translational
- Describe border & functional motions
 - Sagittal plane
 - Horizontal plane
 - Frontal (vertical) plane
 - Posselt's envelope of motion

Joint Capsule

- Superior compartment
 - Extends anteriorly below the articular eminence
 - Allows disc to move forward and support the condyle in extreme movements
- Inferior compartment
 - Extends down the posterior aspect of the condyle
 - Allows condyle to rotate forward against the underside of the disc



Mandibular Movements

Types of mandibular movement

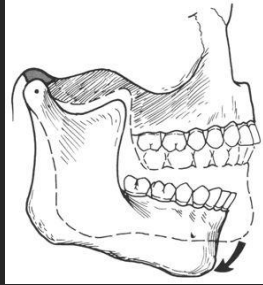
- Basic movements
 - Opening & closing
 - Forward– protrusion
 - Backward– retrusion
 - Lateral gliding movements
- 3 dimensional
 - Rotation
 - Translation
- Mandibular movements are the result of simultaneous & combined movement of both TMJs

Rotational movement:

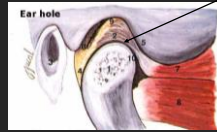
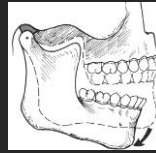
- 1: the action or process of rotating on or as if on an axis or center
- 2: the movement of a rigid body in which the parts move in circular paths with their centers on a fixed line called the axis of rotation. The plane of the circle in which the body moves is perpendicular to the axis of rotation (GPT-7)

Rotational movement & the transverse horizontal axis

- Pure rotation occurs when the mouth opens & closes around a fixed point or axis within the condyles
- This occurs around the **transverse horizontal axis** (terminal hinge axis)
- The teeth can be separated & then occluded with no positional change of the condyles

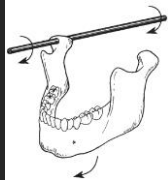
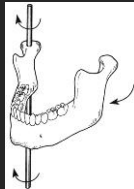
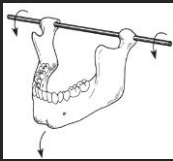


Rotation: where does it occur?



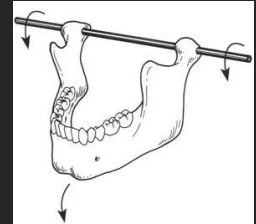
- Rotation occurs within the **inferior cavity** of the joint
- Between superior surface of the condyle & the inferior surface of the articular disc

Reference planes of rotational movement



Rotational movement around the horizontal axis

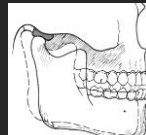
- Movement around the horizontal plane is an **opening & closing** movement
- Referred to as a hinge movement
 - Transverse horizontal axis/ terminal hinge axis
- **Pure rotational** movement
- Condyles are in their most superior position in the articular eminence
- Rarely occurs during normal function



Translation:

- that motion of a rigid body in which a straight line passing through any two points always remains parallel to its initial position. The motion may be described as a sliding or gliding motion (GPI-7)

Translation: where does it occur?



- Translation occurs within the **superior cavity** of the joint
- Superior surface of the articular disc & the inferior surface of the articular fossa

Physiologic rest position:

- the position assumed by the mandible when the attached muscles are in a state of tonic equilibrium. This is usually noted when the head is held upright (GPT-1)
- the postural position of the mandible when an individual is resting comfortably in an upright position and the associated muscles are in a state of minimal contractual activity (GPT-7)

Occlusal vertical dimension of the face seen when the mandible is in intercuspal position and differences in height between rest and occlusal vertical dimension is referred to as interocclusal distance or freeway space

$$VDR - VDO = FWS (2-4 \text{ mm})$$

Factors influencing postural position

- Body & head posture
- Sleep
- Psychic factors influencing muscle tonus
- Age
- Pain, muscle spasm
- Systemic factors: Parkinson's disease, tetanus, etc.

Centric Relation (CR): the maxillomandibular relation in which the condyles articulate with the thinnest avascular portion of their respective discs with the complex in the anterior-superior position against the shapes of the articular eminences. This position is independent of tooth contact. This position is clinically discernible when the mandible is directed superiorly and anteriorly. It is restricted to a purely rotary movement about the transverse horizontal axis.

Maximum Intercuspation (MI): the complete intercuspation of the opposing teeth independent of condylar position.

Centric Relation. Why is it important?

CR is a bone to bone position and MIP is a tooth to tooth position.

CR is the only clinically repeatable (verifiable) jaw relation. It is the logical position to fabricate a prosthesis.

CR and MIP are coincidental in only 10% of the population. The discrepancies between

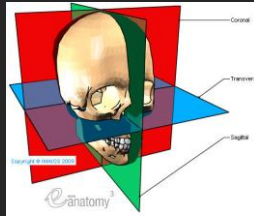
CR and MI can be observed on articulated study casts.

Why is it needed? An accurate CR recording should be made to reduce time spent making intraoral adjustments at delivery.

Border Movements

Single-plane border movements

- Outer range of motion limited by ligaments, articular surfaces & teeth
- When the mandible moves through the outer range of motion, reproducible describable limits called border movements
- Three planes:
 - Sagittal
 - Horizontal
 - Coronal

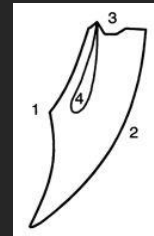


Border movements are limited by ligaments and teeth against the maximal effort of the muscles

Sagittal Border Movements

Border movements: Sagittal plane

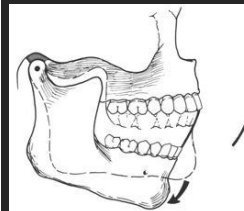
- 4 distinct movement components:
 1. Posterior opening border
 2. Anterior opening border
 3. Superior contact border
 4. Functional



Determinants of movements in the sagittal plane

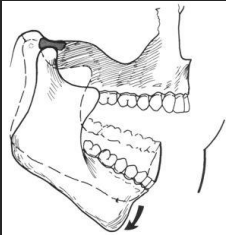
- Superior contact border movements are determined by **occlusal & incisal surfaces of the teeth**
- Anterior & posterior border movements are determined by **ligaments** & the **morphology of the TMJs**
- Functional** movements **are not** border movements
 - They are determined by **the conditional responses of the neuromuscular system**

Posterior Opening Border Movements



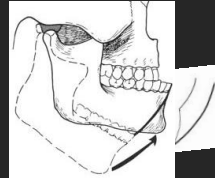
- Occur as two-stage hinging movements
- First stage:
 - The condyles are in most superior positions in the articular fossae (terminal hinge position)
 - The most superior condylar position from which a hinge axis movement can occur is the centric relation
 - The only repeatable hinge axis movement of the mandible
- In CR, pure rotational movement occurs for up to 20-25 mm opening between the incisal edges

Posterior Opening Border Movements



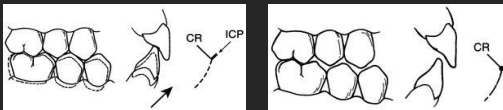
- Second stage
 - The TM ligaments tighten, after which continued opening results in an **anterior & inferior translation** of the condyles
- Maximum opening is in the range of 40 to 60 mm interincisally (capsular ligaments prevent further movement)

Anterior Opening Border Movements



- When mandible is open maximally, contraction of the inferior lateral pterygoids will generate anterior closing border
- Not a pure hinge movement
 - Maximum protrusive position is determined in part by the stylomandibular ligaments
 - When closure occurs, tightening of the ligaments produces a posterior movement of the condyles

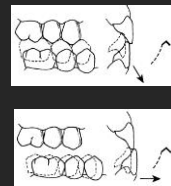
CR & ICP



- CR to ICP slide occurs in 90% of population
 - 1.25 ± 1mm
 - Superoanterior movement
 - Slide may have a lateral component
- When CR=ICP, no superior slide to ICP

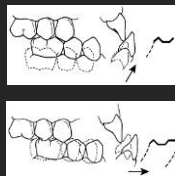
Superior Contact Border Movements

- Horizontal & vertical overlap
- ICP → maximum protrusion
- When the mandible moves forward, the incisal edges of the mandibular incisors & lingual surfaces of the maxillary teeth creates an inferior movement
- Continues until there is an edge to edge relationship- Horizontal movement



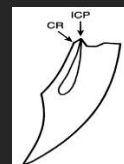
Superior Contact Border Movements

- Mandible moves in superior direction until posterior teeth contact
- Further horizontal slide → maximum anterior position



Functional Movements

- Free movements occurring within envelope of movement
- Most functional activities require maximum intercuspation & therefore typically begin at & below the intercuspal position



Functional Movements

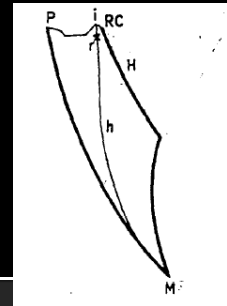
- Movement begins at the ICP & drops downward & slightly forward to the position of desired opening
- It then returns in a straighter pathway, slightly posterior to the opening movement



Posselt's Envelope of Motion

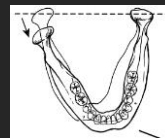
Posselt's Envelope of Motion

- The three-dimensional space circumscribed by mandibular border movements within which all unstrained mandibular movement occurs
- Superior surface → tooth morphology & interarch relationship
- Remaining borders → TMJ anatomy & ligaments



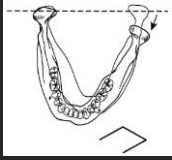
Horizontal Border Movements

LL border movement



- R inferior lateral pterygoid contracts → R condyle anteriorly, medially & inferiorly
- If L lateral pterygoid is relaxed → L condyle remains in CR & result is a left lateral border
- R condyle: **orbiting, non-working**
- L condyle: **rotating, working**

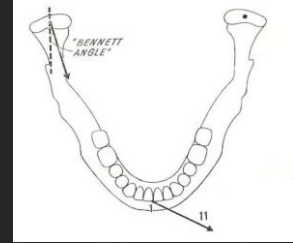
RL border movement



- L inferior lateral pterygoid contracts → L condyle anteriorly, medially, & inferiorly
- If R lat pterygoid is relaxed → R condyle remains in CR & results in a right lateral border
- L condyle: **orbiting, non-working**
- R condyle: **rotating, working**

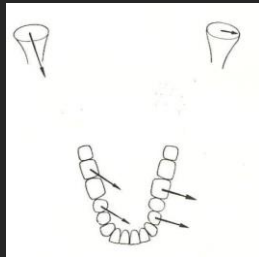
Bennett angle

- The angle formed between the **sagittal plane** & the average path of the **balancing condyle** as viewed in the horizontal plane during lateral mandibular movements (GPT-7)

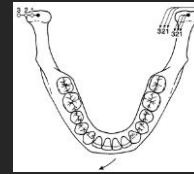


Bennett movement

- The bodily lateral movement in the rotation of the working side condyle as the mandible makes a lateral movement
- Alternative term: side shift
- The amount, direction & timing varies
 - Joint structure
 - Ligament
- Average: 0.75mm



The mandibular lateral translation movement (Bennett)



The more medial the medial wall is from the condyle, the greater will be the lateral translation movement

Frontal (vertical) Border Movements

Border Movements: Frontal (vertical) plane

- "Shield-shaped"
 1. Left lateral (LL) superior border
 2. LL opening border
 3. Right lateral (RL) superior border
 4. RL opening border

