MECHANICS OF MANDIBULAR MOVEMENT
MECHANICS OF MANDIBULAR MOVEMENT

Rotational

Translational
MECHANICS OF MANDIBULAR MOVEMENT

I. Rotational
   1. Horizontal axis
   2. Frontal axis
   3. Sagittal axis

II. Translational
   1. Sagittal plane
   2. Horizontal plane
   3. Frontal plane
Rotation

“the process of turning around an axis: movement of a body about its axis.”

*Dorland’s Medical Dictionary*
ROTATIONAL MOVEMENT

Anatomical Location

- Inferior joint cavity of TMJ
- Superior surface of condyle vs inferior surface of disc
Horizontal Axis

1. Hinge movement
2. *Terminal hinge axis*
   - Condyles in most superior position in articular fossae
   - Mandible pure rotation
   - Clinically discernible
   - Rare in normal function
ROTATIONAL MOVEMENT

Frontal (Vertical) Axis

- One condyle remains in Terminal hinge position - Rotating condyle
- Orbiting condyle
- Does not occur naturally in isolation

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ROTATIONAL MOVEMENT

Sagittal Axis

- Does not occur naturally in isolation
- Limited by ligaments and musculature
- Component of orbiting Condyle movement
TRANSLATIONAL MOVEMENT

TRANSLATION

“a movement in which every point of the moving object has the same velocity and direction simultaneously.”

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TRANSLATIONAL MOVEMENT

Anatomical Location

- Within the Superior Joint cavity of the TMJ
- Superior surface of articular disc vs inferior surface of articular fossa
Normal Mandibular Movements

- Both ROTATION and TRANSLATION occur simultaneously.

- The mandible can be rotating about one of its component axes and the axes can be translating simultaneously.

- Complex movement - difficult to visualise.
POSTERIOR DETERMINANTS OF MANDIBULAR MOVEMENT

Condylar Border Movements
Condylar Border Movements

The periphery of a total volume of space used by the condyles within and outside the glenoid fossae when acted upon by forces in the presence/absence of resistance.
Border Movements

Mandibular movement limited by

- Ligaments
- TMJ articular morphology
- Occlusal morphology & tooth alignment

Outer range or border
POSTERIOR DETERMINANTS OF MANDIBULAR MOVEMENT

Active vs Passive
Considerations in Recording Condylar Postures / Movements

**Force**
- muscle vectors
  - patient vs operator
  - functional vs parafunctional
- resistance employed
  - (eg anterior jig)

**Intra-capsular Constraints**
- normal vs dysfunctional TMJs
MANDIBULAR MOVEMENT

BORDER MOVEMENTS

VS

FUNCTIONAL MOVEMENTS
Envelope of Function

- The individual jaw movement cycle starting from MI and returning to MI in function.
- A 3-dimensional movement.
- A Masticatory Sequence in a composite of several individual envelopes of function (Chewing Strokes) from the beginning of mastication until deglutition.
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

Posselt’s Envelope

1. Posterior Opening Border
2. Anterior Opening Border
3. Superior Contact Border
4. Functional
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

1. Posterior Opening Border
   • Joint morphology & ligaments

2. Anterior Opening Border
   • Joint morphology & ligaments

3. Superior Contact Border
   • Occlusal & Incisal surfaces

4. Functional
   • Conditional response of NMS
MANDIBULAR MOVEMENTS
- SAGITTAL PLANE

1. Posterior Opening Border Movement

• 2 Stage Hinging Motion
• Stage 1
• Stage 2
1. Posterior Opening Border Movement

Stage 1

- Condyles stabilised in most superior position in the articular fossae
- Centric Relation (CR) position
- Pure rotation with no translation of condyle
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

Centric Relation Position

- Hinge movement can theoretically be obtained from any position anterior to CR
- Condyles must be stabilised to prevent translation
- Stabilisation difficult to establish
- Therefore posterior opening border movements that use THA are the ONLY REPEATABLE hinge movements of the mandible.
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

Centric Relation (CR) Position

- Physiologically Acceptable
- Clinically Repeatable
1. Posterior Opening Border Movement

Stage 2

- After 20 - 25 mm interincisal opening
- **TM ligaments** cause anterior and inferior translation
- Axis of rotation shifts to rami- *sphenomandibular ligament* attachments?
Mandibular movements - Sagittal plane

1. Posterior opening border movement

Stage 2

- Anterior mandible moves posteriorly & inferiorly
- Max opening: 40 - 60 mm interincisal opening
- Capsular ligaments limit opening
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

2. Anterior Opening Border Movement

- From maximally open to maximally protruded
- Not a pure hinge movement
  - Posterior movement of condyles from tightening of stylomandibular ligaments
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

3. Superior Contact Border Movement

- Totally tooth determined
- Tooth contact present throughout
- Determinants
  1. CR to MI shift
  2. Posterior cusps steepness
  3. Vertical & Horizontal Overlap of Anterior Teeth
  4. Lingual morphology of Maxillary anteriors
  5. Intraarch relationships

Fig. 4-10. Common relationship of the teeth when the condyles are in the centric relation position (CR).

Fig. 4-11. Force applied to the teeth when the condyles are in centric relation (CR) will create a superanterior shift of the mandible to the intercuspal position (ICP).
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

3. Superior Contact Border Movement

- CR to MI Shift
  - 90% of population
  - Average: 1.25 ± 1mm

- Mesial inclines Max tooth vs distal inclines Mand tooth

- Muscle force applied - superoanterior shift to MI (ICP)

MANDIBULAR MOVEMENTS - SAGITTAL PLANE

3. Superior Contact Border Movement

- **CO to MI Shift**
  - Vertical component
  - Lateral component
- **If CO = MI**
  - No superior slide

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MANDIBULAR MOVEMENTS - SAGITTAL PLANE

3. Superior Contact Border Movement

- **MI** - Anteriors in contact
- **Anterior Guidance**
  - Mand incisors vs Max lingual fossae
  - Anterior inferior movement

edge-to-edge

Maximum protrusion
Fig. 4–12. As the mandible moves forward, contact of the incisal edges of the mandibular anterior teeth with the lingual surfaces of the maxillary anterior teeth creates an inferior movement.

Fig. 4–13. Horizontal movement of the mandible as the incisal edges of the mandibular teeth pass across each other.

Fig. 4–14. Continued forward movement of the mandible results in a superior movement as the anterior teeth pass beyond the end-to-end position, resulting in posterior tooth contacts.

\[ CR = ICP \]

CO = MI
4. Functional Movements

- Within Borders (*intraborder movements*)
- Typically begin at and below MI
MANDIBULAR MOVEMENTS - SAGITTAL PLANE

4. Functional Movements

- Chewing stroke in Sagittal Plane
4. Functional Movements

• **Postural Position**
  • Has been called *Clinical Rest Position*
  • 2 - 4 mm inferior to MI
  • Variable
  • NOT position of minimal EMG activity
Postural Jaw Position

- A muscular position determined by
  - the *elastic* properties of the protein and connective tissue elements of muscle
  - the *superimposed* myotactic stretch reflex generated in the antigravity muscles by the primary afferent innervation of the muscle spindles
Postural Jaw Position

- Incorrectly termed "Rest" Position
- Not a border position
- The static jaw position that arises when the jaw is held suspended from the skull in its neuromuscular sling, when the jaw and facial muscles are relaxed.
4. Functional Movements

- **Postural Position**
  - Myotactic reflex brings mandible from Minimal EMG position to **Postural Position**
  - Functionally Ready position
Mandibular Movements - Sagittal Plane

4. Functional Movements

- Position of Minimal EMG Activity
  - 8mm inferior and 3 mm anterior to MI

- Mandible in EQUILIBRIUM between gravity and Elevator elasticity and resistance to stretching

Head Posture

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4. **Functional Movements**

**Postural Effects**

1. **Head erect**
   - Retruded path of closure
   - Eg. drinking, dental treatment

2. **45° extension**
   - Retruded path of closure
   - Eg. drinking, dental treatment

3. **Alert Feeding Posture** **(30° down)**
   - eg. Eating
   - Heavy anterior tooth contacts
   - Anterior path of closure

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MANDIBULAR MOVEMENTS - HORIZONTAL PLANE

Gothic Arch Tracer

• rhomboid pattern
MANDIBULAR MOVEMENTS - HORIZONTAL PLANE

Movement Components

1. Left lateral border
2. Continued left lateral border with Protrusion
3. Right lateral border
4. Continued right lateral border with Protrusion
5. Functional
Rotating Condyle

- A geometric term better reserved for articulator movement. Refers to the condyle on the laterotrusive side around which lateral movement occurs.
- Pure rotation of the jaw in function does not occur.
- Additional component of lateral, posterior, anterior, superior or inferior movement.
Orbiting Condyle

- A geometric term better reserved for articulator movement rather than jaw movement.
- Refers to the condyle on the **mediotrusive side** that moves downwards, forwards and medially along the guiding incline of the articular fossa.
1. Left Lateral border

- LEFT condyle - Working (or Rotating)
  - stays in CR

- RIGHT condyle - Nonworking (or Orbiting)
  - Anterior, medial and inferior from R inferior lateral pterygoid pull
2. Continued Left lateral border with Protrusion

- R condyle at max anterior position
- Contraction of L inferior lateral pterygoid
- Mandibular midline shifted back to facial midline
3. **Right lateral border**

- **RIGHT condyle - Working** (or Rotating)
  - stays in CR
- **LEFT condyle - Nonworking** (or Orbiting)
  - Anterior, medial and inferior from L inferior lateral pterygoid pull
MANDIBULAR MOVEMENTS - HORIZONTAL PLANE

4. **Continued right lateral border with Protrusion**

- L condyle at max anterior position
- Contraction of R inferior lateral pterygoid
- Mandibular midline shifted back to facial midline
MANDIBULAR MOVEMENTS - HORIZONTAL PLANE

5. Functional

- *Early stage* of mastication
- *Late stage* of mastication
  - moves closer to MI
MANDIBULAR MOVEMENTS - FRONTAL PLANE

Movement Components

1. Left lateral superior border
2. Left lateral opening border
3. Right lateral superior border
4. Right lateral opening border
5. Functional

Not traditionally “traced”
MANDIBULAR MOVEMENTS - FRONTAL PLANE

1. **Left lateral superior border**

- Inferior concave path
- 1° - Interarch relationships & morphology
- 2° - Condyle-disc-fossa relationship
- 2° - Working side TMJ morphology
- Max extent - Ligaments of Working side joint
2. Left lateral opening border

- Laterally convex
- Ligaments cause shift back to midline as max opening approached
3. Right Lateral Superior Border Movements

- Inferior concave path
- $1^\circ$ - Interarch relationships & morphology
- $2^\circ$ - Condyle-disc-fossa relationship
- $2^\circ$ - Working side TMJ morphology
- Max extent - Ligaments of Working side joint
4. Right Lateral Opening Border Movements

- Laterally convex
- Ligaments cause shift back to midline as max opening approached
5. Functional Movements

- Drops down
- Opening determined by bolus size
- Shifts to side of bolus
- Rises up through bolus
- Shifts back to MI
MANDIBULAR MOVEMENTS

Envelopes of Motion

- 3 Planes
  - Sagittal
  - Horizontal
  - Frontal
- 3 - Dimensional Envelope of Motion
  - Superior surface - Tooth contacts
  - Other borders - Ligaments & Joint anatomy
Biological Control of Mastication
The Neuromuscular System
Dento - Periodontal COMPLEX

CMA

CNS

Muscles
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a) GOOD OCCLUSION

b) BRUXER-WORN OCCLUSION

c) MALOCCLUSION
Anatomical Factors

Force Applied  Resistance

Neuromuscular Status

Condylar Border Movements
Anatomical Factors

Force Applied

Resistance

Neuromuscular Status

Condylar Border Movements

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Anatomical Factors

- Accessory joint movement?
- Condition of limiting structures
  - shape of articulating bones
  - condition & position of disc & its attachments
  - condition of ligaments
  - Intra-articular pressure of synovial compartments
  - buffer space constraints during jaw registration
Accessory Joint Movement

Definition: All Movements impossible in the absence of Resistance

Normal vs. Abnormal Accessory Movements

Salter 1955
Anatomical Factors

- Force Applied
- Resistance

Neuromuscular Status

Condylar Border Movements

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Force Applied

- **Type**
  - active
  - passive
  - combination

- **Vector**
  - technique of jaw manipulation
  - operator skill
Anatomical Factors

Force Applied

Neuromuscular Status

Resistance

Condylar Border Movements
Resistance

- *Intra-oral fulcrum*
  - Teeth in contact
    - type of inclines
  - Central bearing tracing device configuration
  - Deprogrammers
    - type (jig, leaf-gauge)
    - site (anterior, posterior)
  - Pivots

- *Hand position*
  - Bimanual jaw manipulation
  - Chin point guidance
Anatomical Factors

Force Applied  Neuromuscular Status  Resistance

Condylar Border Movements

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Neuromuscular Status

- Consciousness & emotional state
- Presence or absence of neuromuscular restraints
  - muscle hypertonicity
  - muscle splinting
  - muscle spasm
  - muscle spasticity
  - muscle contracture
- Postural demands during test
MANDIBULAR MOVEMENTS
Border Movement

**Definition:** Mandibular movement at the limits dictated by anatomic structures, as viewed in a given plane.
Border Envelopes

**Definition:** A condylar border envelope can be thought of as the periphery of the total volume of space used by the condyles within and outside of the glenoid fossae when being acted upon by forces.

*(modified from Williamson)*
Envelope of Function

**Definition:** the 3D space contained within the envelope of motion that defines mandibular movement during masticatory function and/or phonation

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BDS (Hons), MSD
Frontal

Sagittal

MI

Reading aloud

Chewing

Border movement

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