Orthodontics

The Biomechanics of Orthodontic Tooth Movement
Lecture Objectives

• 1. Definition of Terms
  – Scalars, vectors
  – Force, center of resistance, center of rotation, moment, couple

• 2. Biomechanically - types of tooth movement
  – Translation and rotation
 Scalars and Vectors

- Physical properties are mathematically scalars or vectors
- Scalars have a magnitude and no direction e.g., temperature, mass, length, time- algebraic addition
- Vectors have a magnitude and a direction e.g., force, velocity, electric intensity field, acceleration
Vectors

- Direction or sense
- Magnitude
- Point of Application
- Vectors can be collinear, coplanar, concurrent
Resultant of Forces

- Can add or subtract vector (parallelogram law)
- Important to resolve vectors
  - A vector when resolved will have components, resolution is opposite of vector addition
  - Makes addition or subtraction of multiple vectors simple (after resolving into x, y and z axes)
Common point of application
Resultant of forces
Different points of application

Resultant of Forces

A

B

C

D

E
Resolving force into components
Resultant of forces
Force

- A load applied to an object that will tend to move it in the direction of the applied force
- Unit of Force is Newton
- Orthodontic purposes measured as grams or ounces
Center of Resistance

- Free body: center of mass/gravity = point of balance
- Restrained body (tooth): center of resistance (\text{C} \text{res})
Center of Resistance

- A point at which resistance to movement can be concentrated for mathematical analysis (\(=C_{\text{res}}\))
- The center of resistance for a tooth is \(\frac{1}{2} - \frac{1}{3}\) \((40\%)\) root length apical to alveolar crest
- \(C_{\text{res}}\) varies with alveolar crest height
Center of Resistance

- $C_{res}$ varies with root length and alveolar crest height
Moment

- If the line of action of a force is at a distance from the center, the force will produce some rotation. The potential for rotation is measured as a moment.
Moment - Magnitude

- Magnitude = $F_d = \text{magnitude of force} \times \text{perpendicular distance from Cres to the line of action (unit = gram mm)}$
- Direction: Clockwise or counter-clockwise
Couple

• No single force can use pure rotation
• Only a couple can
• Two forces: equal magnitude; parallel and non-collinear; opposite sense
Couple

- Two forces; equal magnitude; parallel and non-collinear; opposite sense
- Translational effects cancel each other out
Couple in orthodontics
Types of Tooth Movement

- Translation
- Rotation
- Combination/Tipping
Translation = Bodily Tooth Movement

- A force applied in line with the center of resistance: the tooth is translated with no rotation relative to the force.
- Orthodontically, the point of attachment (e.g., a bracket with a hook) is irrelevant: the line of action of force determines the effect on the tooth. If force to hook, then line of action from hook.
Translation or Bodily Tooth Movement
Tipping Tooth Movement

- A force that doesn’t pass through $C_{res}$ causes translation + rotation = tipping
  i.e., tends to tip the tooth, movement with a rotational component
Center of Rotation $C_{\text{rot}}$

- The point around which rotation occurs when an object is being moved
- This point will vary depending on the force/moment/couple being applied
Center of Rotation $C_{\text{rot}}$

- Connect the before and after positions of 2 points
- The intersection of the perpendicular bisectors of these lines is $C_{\text{rot}}$
## Tooth Movement and Crown Rotation

### Type of Movement
- Translation
- Uncontrolled tipping
- Controlled tipping
- Root movement

### Center of Rotation
- Infinity
- Slightly apical to Crown
- Apex
- Incisal edge
Bodily tooth movement is achieved in orthodontics by applying a couple at the bracket level
Summary

- Force is a vector, addition and resolution
- A force through the Cres can produce translation, Cres is midway on root
- By applying a couple you can get rotation
- Tipping results due line of action in orthodontics is at the level of the bracket
- Crot varies with type of tooth movement, where is the Crot for a single force application
National Board Part II Questions

- When a simple tipping force is applied to the crown of a single-rooted tooth, the center of rotation is usually located
  - at the apex
  - at the cervical line
  - 5 mm. beyond the apex
  - one-third the tooth length from the apex
  - two-thirds the root length from the apex

- Simple = uncontrolled
• When an uncontrolled tipping force is applied to the crown of a single-rooted tooth, the fulcrum is usually located
  – at the apex
  – at the cervical line
  – 5mm. beyond the apex
  – 1/3 of the root length from the apex
Questions