Biology of Tooth movement

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>Orthodontics = Thysics + Biology

➢ Orthodontics is basically a specialty where in mechanics and biology are integrated to bring about a realistic and practically acceptable tooth movement.





 By 1983, various chemical mediators were identified to be the cause of cellular differentiation during tooth movement and different theories of tooth movement were postulated.

Tooth movement mainly a "periodontal ligament phenomenon"

PDL = Collagenous fibres + Cellular elements + tissue fluid





1) CONNECTIVE TISSUE CELLS A. SYNTHETIC CELLS

B. RESORPTIVE CELLS

2). EPITHELIAL REST CELLS -

8). DEFENSE CELLS

Fibroblasts Cementoblasts Osteoblasts

Osteoclasts Odontoclasts Cementoclasts

Epithelial rests of malassez

Macrophages
 Mast cells
 Eosinophils

Physiologic tooth movement

1.Tooth eruption- Blood pressure theory

- Root growth
- Hammock ligament
- Periodontal ligament traction theory

2. Migration or drift of teeth

3.Tooth movement during mastication



Histology of tooth movement



- 1. Changes following application of mild forces
- 2. Changes following application of extreme forces

Changes in Pressure side



Pressure side





Tension side



Secondary remodelling changes:



2. Changes following application of extreme forces



Frontal resorption

Undermining resorption





- Forces that bring about orthodontic tooth movement are continuous and should have a minimum magnitude (threshold)
- Below this threshold limit, the PDL has the ability to stabilize the tooth by active metabolism
- The optimal force required is **20-25** gm/cm^{2.}

The optimal force has the following characteristics:

- 1. Produces rapid tooth movement
- 2. Minimal patient discomfort
- 3. The lag phase of the tooth movement is minimal
- 4. No marked mobility of the teeth being moved

In Histological point of view:

- 1. The vitality of tooth and supporting PDL is maintained
- 2. Initiates maximum cellular response
- 3. Produces direct or frontal resorption

Deleterious effects of force

- Gingival effects
- Pain and mobility
- Pulp effects
- Effect on root
- Effect on alveolar bone:

 due to imbalance between resorption and bone formation or due to increased gingival inflammation.

maximum of 1mm loss has been observed.



Elimination of hyalinized tissue:

 Resorption of alveolar bone by osteoclasts differentiating in the peripheral intact periodontal membrane and in adjacent marrow spaces.

Invasion of cells and blood vessels from the periphery of compressed zone.





- a) Tipping
- b) Tipping with excessive force
- c) Bodily tooth movement



Burstone (1962) described three phases of orthodontic tooth

movement.

- (1) Initial phase 24-48 hrs- 0.4 to 0.9mm
- (2) Lag phase 20-30 days
- (3) Postlag phase







Theories of tooth movement

Pressure tension theory by Schwarz
 Blood flow theory by Bien
 Bone bending and Piezoelectric theory Farrar









Farrar (1876) - Bending of interseptal alveolar walls

Piezoelectricity - a phenomenon observed in many crystalline materials in which a deformation of the crystal structure produces a flow of electric current as electrons are displaced from one part of the crystal lattice to the other.



Collagen
Hydroxyapatite
Collagen –
Hydroxyapatite interface
The mucopolysaccharide

1. Quick decay rate

2. Production of an equivalent signal in the opposite direction upon force removal







Bone formation: Osteoblasts & Osteocytes:













Bone Resorption: Osteoclasts:



Biochemical reaction to Orthodontic tooth movement

Mechanical stimulus —> Biological response











•Cytokines are extracellular signaling proteins that act on nearby target cells in low concentrations during cell-to-cell communications.

 Cytokines that were found to affect bone metabolism, and there by orthodontic tooth movement



Arachidonic acid metabolites



Role of Secondary messengers in OTM

CAMP Pathway:



CGMAP- Intracellular regulator- **cGMP dependent protein kinases**

