A to Z ORTHODONTICS

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TISSUE CHANGES

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Terminology used in Biomechanics

**Force**: compression, tension, bending, shear, and torsion

**Deformation**: Change of form due to the loading of forces

**Stress**: the force per unit area

**Strain**: the dimensional change expressed as a fraction (ratio) of the subject’s original size

**Force**

1) **Two basic forces**: Compression & Tension
2) **A combination of compression and tension**: Shear & Bending
3) **A combination of the above four forces**: Torsion

Compression: compression is the direct expression of the force, which pushes everything towards the center of an object.

Tension: the opposite of compression; the force which pulls everything away from the center; where there is a compressive force, there must be a tensile force.

Shear: shear is present, when two forces are thrusting in opposite directions but offset and slide past each other.

Bending: is found between the pulling of tension and the pushing of compression.
Torsion: a result of all the other four forces. Torsion is twist. Torsion is actually a specialized bending, a circular bending.

**Drift vs Displacement**

Drift: the growth movement of an enlarging portion of a bone by the remodeling.

Displacement: The growth movement of a whole bone as a unit.

Direction of growth: the net growth direction of drift plus displacement.

**COUPLE:**

It is a pair of concentrated forces having equal magnitude and opposite direction with parallel but non collinear line of action. A couple when acting upon a body bring about pure rotation.

**MOMENT**

It is a measure of rotational potential of a force with respect to specific axis.

Moment = magnitude of force × distance

**What is mechanics?**

It is defined as that branch of engineering science that describes the effect of force on the body.

Theories of mechanics have potential applications in following 3 areas--:

- Precise application of forces
• A better understanding of clinical and histological response to various magnitudes of forces
• Improving the design of orthodontic appliances.

Everybody continues in its state of rest or of uniform motion in a straight line, unless it is compelled to change the state by forces impressed upon it (Sir Isaac Newton) and teeth are no exception.

CENTER OF RESISTANCE
The center of resistance (CR) of a tooth is the point of concentrated resistance to movement. In free space, CR is the center of the tooth which happens to correspond to the center of gravity of the tooth.

When the tooth is in the mouth, the tooth is embedded in bone. The CR now shifts to the center of the portion of the tooth embedded in the bone.

ROTATION
Rotation is the movement a tooth makes as it spins around its center of resistance (CR). Although CR's position differs for a tooth in free space versus a tooth embedded in bone, rotation always occurs around CR.
Tissue changes in orthodontic tooth movement:

Each tooth is attached to and separated from the alveolar bone by collagenous. Supporting structure known as the periodontal ligament. Under normal condition it occupies 0.3-0.5 mm in width. Most of the periodontal ligament space is taken up by collagenous fiber bundles. Two other major components are:

1. Cellular elements:

Mesenchymal cells and their progenies in the form of fibroblast, osteoblast, vascular and neural element.

2. Tissue fluids:

Remodeling and recontouring of the bony socket and cementum of the root is constantly carried out through on a similar scale as a response to normal function.

Normal alveolar bone consists of a layer of compact lamilated bone which lines the socket and the surface of the bone under the oral mucosa with the cancellous or spongy bone in between two compact layers. The bone labially and buccaly to the tooth is almost compact with the exception of 3rd molar. Bone and cementum are resorbed by osteoclast and cementoclast respectively.
Response to normal function -

During mastication, the teeth and supporting periodontal structure are subjected to intermittent heavy loads or forces. When a tooth is subjected to intermittent heavy loads, quick displacement of the tooth within the periodontal space is prevent by the incompressible tissue fluid. The force is transmitted to the alveolar bone by the periodontal fibers which give cushioning effect and the act as a shock absorber, very little of the fluid within the space is squeezed out during the first few second of pressure application. When the pressure is maintained the fluid rapidly escapes and the tooth displaces within the periodontal spaces, compressing the ligament against the bone.

Types of tooth movement -

1. Tipping movement -

Under the light force with this type of movement the tooth tilts around a fulcrum situated on the long axis of the root near the apex. With heavy force it (fulcrum) moves towards the cervical part of the tooth. In simple tilting movement, the root moves in opposite direction of crown.

Uncontrolled Tipping
Uncontrolled Tipping (UT) is the motion created by single force acting at a distance from the center of resistance (CR) of a tooth.

**Controlled Tipping**

Controlled Tipping (CT) is the motion of a tooth that has a force applied at a distance from the center of resistance (CR) and has a counterbalancing couple (CBC) to regulate the rotation of the tooth.

2. **Bodily movement** -

Here the tooth moves bodily through the bone i.e, both crown & root is moved in the same direction. This type of movement can be given by fixed appliance requires a strong anchorage.

3. **Extrusion or Elongation** -

Tooth is moved towards the occlusal plane. Fixed appliance is required for their type of tooth movement.

4. **Intrusive or depressive** -

Here the tooth is moved toward the socket. This type of movement also requires fixed appliance but sometimes lower labial segment is depressed with the anterior bite plane with removable appliance.

5. **TORQUING** -

It can be considered as a reverse tipping characterized by lingual movement of tooth.
6. UPRIGHTING

During orthodontic treatment, crowns of certain teeth will be tipped in a mesio-distal direction with the roots tipped in an opposite way. Tipping these roots back to get a parallel orientation is termed uprighting.

All movements are classified basically into following 3-

- Pure translation
- Pure rotation
- Generalized rotation

Types of force

Based on duration of application

1. Continuous force
2. Intermittent force
3. Interrupted force

Continuous Force

- Force is considered continuous if its magnitude does not decrease appreciably over time
- Produces most efficient tooth movement

Intermittent Force

- These decline to 0 magnitude intermittently, when the appliance is removed by patient or clinician
• Movement is mainly due to undermining resorption

Interrupted Force

- These decay to 0 between activations
- Initial forces are high & decreased over time to 0, this gives time for the tissues to recover before the force system is reactivated

**Tissue change during orthodontic force:**

The response of a heavy force against the teeth reach to rapidly developing pain, necrosis of cellular elements within the periodontal ligament and undermining resorption of alveolar bone takes place near the effected tooth. Higher forces are compatible with survivable of cells within the periodontal ligament and remodeling of the socket takes place by a relatively painless frontal resorption of tooth.

There are two major theories of orthodontic tooth movement.

1. Bio- electric theory (bone metabolism is not well established)
2. Pressure tension theory: This theory relates tooth movement at cellular level produced by chemical messenger.

**Histology of Tooth movement:**
Histological changes seen during tooth movement vary according to the time and duration of force applied. The histological changes seen during tooth movement can be studied under two heading as:

A) Changes following application of mild force.

Ideal or mild force: 25-30gm or 1 ounce / single rooted tooth / sq cm of root surface.

When a force is applied to a tooth, pressure and tension areas produced.

**Changes on pressure side:**

The area of the tooth towards the direction of force is called the pressure side

(1) Periodontal ligament in the direction of the tooth movement gets compressed to almost $\frac{1}{3}$rd of its original thickness.

(2) A marked increase in the vascularity of PDL.

(3) This blood supply helps in mobilization of cells such as fibroblast and osteoclast.

(4) The Alveolar cortical bone is transformed.

(5) Adjacent to the tooth surface there is resorption & opposite there is deposition.

**Changes in tension side:**
The area of the tooth opposite to the direction of force is called the tension side.

1) The periodontal membrane on the tension side gets stretched.

2) Thus distance between the alveolar process and the tooth is widened.

3) Raised vascularity on the tension side.

4) Mobilization of cells such as fibroblast and osteoblast in this area.

5) In response to this traction, osteoid is laid down by osteoblasts in the periodontal ligament immediately adjacent to the lamina dura.

6) This lightly calcified bone in due course of time matures to form woven bone.

7) This process of wearing and building up continuous as long as there is force. This remodeling mainly takes place by resorption in the pressure area and deposition in the tension area.

In the pressure area osteoclast disappears – in two weeks time and osteoid is deposited over the area resorption. Fibroblast produced new fibers. This is now the normal architecture of the tooth socket in maintained. This is completed in 6 wks time.

(B) Changes following application of extreme force:
Whenever extreme forces are applied to teeth, it results in crushing or total compression of PDL.

**On the pressure side** –

1. The root closely approximates the lamina dura,
2. Compresses the PDL.
3. Leads to occlusion of the blood vessels.
4. The ligament becomes deprived of its nutritional supply leading to regressive changes called hyalinization [cell free area].
5. Bone resorption occurs in the adjacent marrow spaces and in the alveolar plate below, behind – above the hyalinized zones. This kind of resorption is called under mining or Rearward resorption.

**On the tension side:**

1. The PDL gets over stretched leading to tearing of the blood vessels and is chemia.
2. Increase in osteoclastic activity as compared to bone formation with result that the tooth becomes bone formation with result that the tooth becomes loosened in its socket.
3. In addition, pain & hyperemia of the gingiva may occur due to application of extreme forces during orthodontic tooth movement.
(4) Thus in very heavy pressure there is resorption on both sides

[pressure & tension].

It takes 6 weeks time for the normal cell to reappear.

**Changes in other tissue and bones –**

1. Cementum – Even the lighter force used for the orthodontic treatment resorption may appear in the cementum. Once force is withdrawn repair takes place by cementoblast.

2. Dentin – Cementum resorption may be followed by the dentin in severe pressure such area of dentin are repaired by cementoblast.

3. Pulp – High forces may cause hyperemia of the pulp where as extreme force lead to degeneration and or complete necrosis. Intrusion may not cause circulatory disturbance. Teeth with in the incomplete root formation mat show abnormal development following intrusive tooth movement. Non vital tooth can be moved orthodontically if periodontal ligament and cementum are vital.

4. Basal bone – Changes in size and shape of the maxilla and mandible are limited in general to the alveolar process only.
5. Gingival tissues – Gingival tissues adjust slowly in its new position. In rapid movement there is piling of gingival tissues toward with the tooth is moving.

6. TMJ – Temporal, glenoid and condylar bones changes in occlusion may bring minor change. According to ‘Breitner’ bone resorption and deposition on glenoid fossa and on articular eminence on one hand and around condylar head on another hand was found in monkeys.

**Effect of excessive force –**

1. Loss of anchorage.

2. Resorption of tooth or root involving cementum and dentin.

3. Fulcrum shift during tooth movement.


5. Less movement due to hyalinized tissue formation.

6. Injury to periodontium.

7. Increased relapse tendency due to hamper in orderly deposition and maturation of bone.

8. Dilacerations or deformity of developing roots.

9. Increased intrusive force may cause vacuolization of blood vessels.
Rate of tooth movement depends on –

1. Value of force
2. Age of individual.
3. Surface area of root or roots.
4. Bone area concerned.
5. Direction movement
6. Individual variations
7. Type of tooth movement.

Delayed movement of tooth –

1. Inadequate force.
2. Excessive force.
3. Obstruction by acrylic plate.
4. Force acting for a short period only.
5. Cuspal interference.
6. Movement through compact bone.
7. Movement in elderly patient.
8. Long rooted and multi rooted tooth.
9. Ankylosis
10. Lack of space.
11. Movement against soft tissue balance.

12. Individual’s variation.

13. Increased tendency of stretched fibers to come back in its original position.

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Dedicated To

My Mom, Zubaida Shaheen
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