Sheet no. : 10

Refer to: -Hardcopy slides

-Contemporary Orthodontics; Proffit “The Biologic Basics of Orthodontic Therapy”

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You only need to focus on the information written here, plus the parts we’re guided to study from the book

**“Biomechanics of orthodontic tooth movement”**

* **Its definition: the reaction of dental and facial structures to the orthodontic forces**; either directly on the tooth itself or on the skeletal structures of the maxilla, the mandible or the TMJ, so the force is transmitted to the skeletal structures through the teeth.
* **In order for the teeth to produce any orthodontic movement you need to have the following structures:**
1. **A tooth**
2. **PDL**
3. **Bone**
4. **The force that will be sustained for a certain period of time.**
* To remind you of **the structure of the PDL:**
* **Collagenous fibers** run from the cementum on the root to the bone on the lamina dura obliquely, they become more oblique as we go apically. This arrangement resists tooth dislodgement or extraction so it keeps the tooth in place during mastication
* **Cells**: undifferentiated mesenchymal cells, osteoblasts, osteoclasts, fibroblasts, fibroclasts
* **Blood vessels**
* **Nerve endings**
* **Tissue fluids**

The PDL space is only 0.5mm in width

* Obviously there’s always remodeling in the bone and in the cementum, they are removed constantly and always replaced so remodeling occurs naturally during physiological movement of the bone and the teeth.
* Bone, cementum build up by:

Osteoblasts, cementoblasts

Derived from: local osteoprogenitor cells

* Bone, cementum removal by:

Osteoclasts, cementoclasts

From: multinucleated cells that come normally from the blood stream and are of hematogenous origin.

The above is what happens *normally* if you don’t have a sustained orthodontic force.

* **Theories of how teeth move:**

They’ve said that maybe it’s the biologic electricity that causes the teeth to move, others say it’s the pressure-tension

1. **The bioelectrical theory**
* States that there are electrical signals that are elicited so when the bone bends when we bite there’s some efformation in the cells, this elicits electrical signals and these cause change in the bone metabolism.
* The electrical signals aka **the Piezoelectrical signals** are generated through stress; when you apply stress on the bone you deform the cell, which elicits signals and this is seen in crystalline materials
* This signal is important for maintaining the normal skeletal function but it quickly decays/disappears so apparently it’s not the one responsible for explaining the orthodontic tooth movement.
* Electrons are displaced in the crystal lattice when you have deformation of a crystal structure and then you have this electric current.
* However, because it’s also observed in bone that is not being stressed, they found that when you apply electric signals to bone it kind of increases the rate of tooth movement so it does play a role for it changes/increases cell activity, it’s not really well-understood how it does that. So it’s not the theory responsible for tooth movement, yet it has an effect on it. There are experiments that have been carried out, in which they’ve put an electrical signal and they found that the rate of movement in the cells became greater; they differentiated at a greater rate than other cells, so it might have an action on increasing the rate of tooth movement but again tooth movement per se cannot be just explained by bioelectric theory.
1. **The pressure-tension theory** explains tooth movement better.
* When you have a sustained pressure or force on a tooth it causes alteration in the blood flow stimulating the release of chemical messengers.
* The following happens when you bite on a tooth with a heavy force during mastication (1-50)kg;
* the **first second** nothing really happens, the PDL fluid is there and it’s incompressible then the bone bends a little bit and then we have the piezoelectric signals
* if it’s sustained for a little bit longer **(1-2) seconds** PDL fluid is expressed and the tooth moves a little bit within the PDL space
* if sustained longer than this this **(3-5) seconds** PDL fluid is expressed and the tooth moves and hits the wall of the bone so it causes pain, so the tissues are compressed and this causes pain.

For orthodontic movement to occur you need to have a sustained force for a long period of time not just for few seconds or hours.

* Before talking about the compression area and the tension area you need to know the following movements:
* **the tipping movement:** when you apply a single force on a crown the tooth tips; the crown moves in a direction and the root moves in the opposite direction, so we have the area of compression to which you’re pushing the tooth and where the root hits the wall of the bone, the others are the areas of tension.



Area of tension

Loading diagram

 Area of compression

* **The bodily movement**: When the crown and the root move in the same direction, it can only be applied using fixed appliances, you cannot apply it using only a single force you need a couple of forces, the area of compression in this movement is greater; that’s why we need a greater force in order to achieve the bodily movement (translation). The loading diagram is along the whole surface of the root .



Area of tension

* **The optimum forces that are required for tooth movement** without producing any detrimental effects on the root and the bone; the higher the forces the greater the damage created so these are the optimum forces for

-**Tipping movement 🡪 (35-60) g or (25-60) g** in some sources

-**Bodily movement 🡪(70-120) g** almost the double of the tipping forces

Less than those optimum forces no movement would be detected

* **Light forces:**
* We need light forces to produce the optimum movement of the tooth.

What happens when you apply these optimum forces on a cellular level?

First of all when you apply a force, PDL fluid is expressed out, the tooth moves within the PDL space in seconds. If the force is maintained this will cause compression of the blood vessels a little bit so the blood flow alters which elicits the cellular changes.

* Prostaglandins (E) and cytokines, IL-1, GF and other chemicals are released within minutes which are the ones that will elicit cellular activity this will increase the cAMP levels which will elicit the **cell differentiation into osteoclasts, osteoblasts…etc. after 4 hours** of applying a light force and **the tooth will move** **within two days**.
* **Role of Osteoblasts and Osteoclasts:**

Osteoclasts (located mainly in the compression area; for we want to remove bone in this side, they’re derived from mucous cells and also can migrate for distant area and they remove the bone directly) and osteoblasts (located in the tension area; because we want to build bone) both are stimulated by prostaglandins.



* Figure in slide no.18:

Light force on lamina dura, all the osteoclasts are active on one side so they start removing bone from the wall of lamina dura and the tooth moves gradually, so its directly from the adjacent lamina dura, this is called **frontal/direct resorption.**

Osteoblasts that form the bone on the tension area, so remodeling takes place and this happens within 2 days.

* **Heavy forces**
* We totally occlude the blood vessels 🡪 no blood flow 🡪 necrotic cells around this area 🡪 no cell activity on the wall of lamina dura
* When you look at it microscopically it appears like it has a glassy appearance that’s why it’s called **hyalinization**
* Cell differentiation (osteoclasts) does occur but not on the surface, it occurs somewhere on the underside of lamina dura adjacent to hyalinized area and for this activity to occur it takes **3-5 days** (not 4 hours) and it takes **7-14 days** for the bone to be eaten away and for the tooth to move/jump into new position (not 2 days).
* Why tooth movement takes a longer time than that with light forces?

Because for the cell to get the message of differentiation to osteoblast or osteoclast it takes a longer time because the blood vessels are occluded.

* **Undermining resorption** results, because cells from the underside of lamina dura are being eaten away and this takes longer for the cells to differentiate and for the tooth to start movement
* Figure in slide no.21:

Tension or stretching is present and this is all damaging to the tooth if it occurs constantly.

* Heavy forces can be applied not intentionally. Some patients ask the orthodontists to move teeth using heavy force thinking that this will accelerate the tooth movement, but the rate of teeth movement over a period of months despite the amount of the force (heavy, light) will be almost the same in the end, but heavy force has detrimental effects on teeth and the surrounding structures whereas light continuous force is good.
* Graph in slide no.23:

This is what you get when you apply heavy forces; no movement then suddenly the tooth jumps and this is repeated. Light force is more continuous.

* **Supra-alveolar Connective Tissue**

This is just to tell you that there’s always residual tension in the transseptal fibers and this is what causes movement, sometimes when you want to move a canine the adjacent lateral incisor moves along with it due to the transeptal fibers and it takes longer for the free gingival fibers to reorganize and remodel and that’s why rotated teeth have high relapse possibility, so once you finish the orthodontic treatment you have to put a fixed retainer to keep them in place for a long period of time in order to allow for the reorganization of the fibers and sometimes they do sth called **circumfrential supercrestal fibretomy** to minimize this relapse. This explains the movement of the other teeth when you move one tooth.

* Pressure-tension theory. We need the following:
1. a good **force magnitude**
2. **force duration** (certain hours) minimum of 6-8 hours to start the tooth movement, the longer the duration of the force the more active the tooth movement is. You have to know that the force decays, the tooth magnitude decreases as the tooth moves. When using palatal finger spring and Z-spring you have to see the patient a month later because the force decays and this is not effective to produce tooth movement anymore so we have to reactivate the appliance, obviously we can’t do the high amount of activation initially as mentioned earlier
3. **force distribution** and the type of movement you’re producing; tipping or bodily
* **Force duration is classified as:**
1. **Continuous force** when you have a force which is maintained between activation, almost the same amount of force maintained between activation
2. **Interrupted force** is when suddenly the force drops to zero between activation and this occurs when the appliance is inactive anymore
3. **Intermittent force** when it declines abruptly to zero if the appliance is removed by the patient; i.e. the force is there in the appliance but when its removed by the patient there’s no force anymore so the tooth doesn’t move and it resumes when it’s inserted again this occurs with head gears and with removal appliances, you can find almost all forms in most appliances, i.e. at some point when you take fixed appliances you’re going to have interrupted forces as well
* Figure in slide no.28:

This is how it looks like the continuous force is maintained along a month, interrupted force drops to zero when the appliance is inactive, when removed its intermittent force.

* **Torqueing** is when you’re moving the root and holding the crown which requires a high amount of force almost equal to the bodily movement
* **Rotation** is like the tipping movement if you apply force on one side of the tooth it rotates around the center of that rotation. If you don’t want the root to rotate you need to apply it on the middle of the root.
* **Extrusion** doesn’t require that much force, here you have a large area of tension and compression
* **Intrusion** pressure is only on the apex of the tooth so you need a very minimal force 10-20g only otherwise you cause root resorption, because it has a very small area of tension and compression

Normally more than one force is applied at the same time

* **Anchorage** in orthodontics

“For every action there’s an equal but opposite reaction” and this applies in orthodontics. Anchorage in orthodontics is **“the resistance to unwanted tooth movement”** like when moving one tooth the rest will also move and sometimes we don’t want that.

* Slide no.36:

Palatal finger spring appliances are moving the teeth distally in the arch. What happens when you apply a force like this on the tooth is that we’ll have the exact amount of force in the opposite direction, we cancel it if we want to keep the molars in place to preserve the space available. Because the base plate is attached to all the teeth, it can move all the other teeth in the opposite direction it’s going also to cause proclination of the anterior teeth. To know whether you’re losing the anchorage or not you need to check the overjet or the molars position.

* **Optimum Force:**
* Lightest force that produces maximum response to orthodontic force. Tooth movement depends on the optimum force, so a force lower than the optimum is applied no movement would be detected.
* Force depends on total root surface area of a tooth. Moving only a single tooth for example, which has a root surface area of a certain amount needs a certain amount of force. Tipping requires 60g, 50g is not enough to move a multi-rooted tooth (a molar) with a large total tooth surface area so it needs a higher force. Having this concept in mind if you just move a single tooth against a lot of other teeth they’re not going to move as a reaction.

If we’re moving a second premolar for example we use all the rest teeth as anchorage, the 50g force that I’m using to move this tooth is going to be distributed on 6 4 3 2 1 when we calculate the amount of force on each it might be 10g or 5g which is not enough to produce a movement, so one way to produce an anchorage is to incorporate as many teeth in the anchor unit as possible, i.e. when I’m moving one tooth I use all the rest teeth for anchorage.

A multi-rooted tooth give me more anchorage than the single-rooted one.

* Slide no.39:

The sum of the anchorage value on anterior teeth is equal to the 5 and 6 teeth. If you want to move the anterior teeth into the space of first premolar, half of that space will be occupied by ant teeth and the other will be occupied by the 5 and 6, so if you need more than half of that space to relieve anterior crowding and to retract the ant teeth you need to think of how to increase your anchorage.

* **Forms of Anchorage**
1. **Intraoral**; inside the mouth so basically you can use it either
* **Intermaxillary** (between the arches) is when you take anchorage from the other arch, this way we’re bringing the anterior teeth posteriorly I want to cancel this force so we put an elastic band which produces a force.
* **Intramaxillary** (within the same arch)
1. simple
2. reciprocal
3. stationary
* **The soft tissues** of the mouth
1. **Extraoral** anchorage like head gears
2. **Skeletal (absolute)** applied from plates that are in touch with the bone

Best wishes