Endodontics lecture 2

The reading material

**Seltzer and Bender’s Dental Pulp**

**The dental pulp organ**

The science of endodontics means to study the periradicular tissues of the tooth, including the dental pulp. And taking in consideration to the causes of the pathological effects.

The dental pulp acts as an alarm system and plays a major role in both local and systemic health

The tooth pulp, is the soft inner most tissue. It’s an unmineralized connective tissue, containing blood and lymphatic vessels, in addition to nerve fibers.

Pulp composition:

* 75-80% water
* 20-25% organic components

There’re no inorganic components found in the pulp, unless when pulp stones are formed due to pathological conditions as a result of tooth aging.

Pulp and dentine have the same background and characteristics, but differ in their compositions. Once both are formed, they act together upon stimuli as one functional unit. This fact has an importance when considering regeneration and vascularization of the tissues.

The pulp occupies the center of the tooth, and under normal conditions, it starts forming dentine facio-lingually and mesio-distally. Anatomically, we can observe a stream of connective tissue extending from the periodontal ligament, passing through the apical foramen, reaching the pulp cavity . Each root is served by at least one pulp corridor.

Pulp is referred to as the nerve, since during any pathological effect; pain illuminates from it. But we use the term pulp as mentioned previously for 2 main reasons:

* Location, found in the center of the tooth
* Characteristics, fleshy and contains vessels among with nerve fibers.

An intact pulp can be extracted as a single piece, being fleshy and having a pink color due to its vascularization. But it’s rare to extract the pulp as a single piece, the reason behind that is because of the ground substance forming the pulp which is composed of gelatin like material. The ground substance contains nerve cells, blood and nerve fibers that form the dental pulp organ.

When the pulp is extracted from the dentine; which used to be acting as a shell, it’s exposed to air and therefore, the fluid evaporates. This changes the appearance and volume of the pulp.

Architecture of the pulp:

Has 2 main zones: Center and peripheral

From innermost to outermost, Pulp core 🡪 cell rich zone 🡪 cell free zone 🡪 odontoblastic layer

The pulp core is the zone where the nerve tissues and vessels initiate, running towards the peripheral zones to finally reach the dentine.

Cell rich zone contains fibroblasts and undifferentiated mesenchymal cells, these cells act as a reservoir to replace worn away odontoblasts. Odontoblasts are responsible for the formation of dentine, hence, called dentinoblasts. They’re mainly found in the coronal pulp, but could exist in the radicular pulp.

Cell free or cell poor zone is also called the cell zone of Weil, containing capillaries and nerve networks. They function in replacing demolished odontoblasts, same as neighboring cells from the cell rich zone. The nerve fibers found in the cell free zone have no myelin sheath, referred to as free nerve endings; these are the specific receptors of pain in the dental pulp. Central to the cell free zone, we find the sub-odontoblastic nerve plexus of Raschkow; it’s responsible for painful sensations and inflammatory events, hence, functioning in tissue repairing.

The outermost zone is the odontoblastic layer, derived from its name, containing odontoblasts which serve in dentine formation. Odontoblasts’ cell bodies are found in the pulp while their processes possess in the dentine. When odontoblasts get irritated, they start performing one of the pulpo-dentinal complex’s functions:

* Tubular sclerosis
* Irritation; formation of secondary dentine
* Inflammation of the underlying connective tissue

Since the main function of the pulp is to produce dentine, vitality of the tooth depends on the health of the pulp. The loose connective tissue of the pulp performs 4 main functions:

* Formation of dentine, this function provides an intact cycle throughout the whole life of the tooth. And therefore, dentine acts as a shell to cover the pulp
* Defense, secondary dentine is produced for protection when irritated or by a trauma.
* Sensation ( nervous sensory function) , necessary for vasomotor and defense.
* Nourishment, the vascular network of the pulp is able to supply all of the vital elements of the pulpo-dentinal complex; transporting oxygen and nutrients to the odontoblasts. In addition to fluids to prevent the tooth from becoming brittle.

Like any other loose connective tissue, the pulp needs a network of nerves to be able to proceed with its functions. The nerves found in the pulp are free nerve endings.

The environment of the pulp deserves serious consideration:

The pulp has a low compliance when it comes to expansion, since it’s enclosed by the mineralized tissue; dentine. When inflammation occurs, the first mechanism that results is vasodilation; this allows blood vessels to increase the amount of fluids being released. The poor expansion due to compliant enclosure is the cause of the pain, that’s why even the smallest infection could allow us to exhibit painful sensations from Inflammation of the pulp 🡪 pulpitis.

The ground substance of the pulp, is composed of carbohydrate & protein complexes. These complexes, along with saccharides, provide optimum media for the cells. Mechanism:

* Nourishment, transports nutrients to the functioning cells.
* Metabolism, transports wastes and degraded cells to the blood and lymphatic channels.

Any change in the composition of the ground substance, as in tooth aging, will result in disruption in the inflammatory responses and the transporting mechanisms. The ground substance also acts as a barrier against harmful micro-organisms. Some bacteria might release enzymes which are capable of dissolving the ground substance, hence, acquiring a higher possibility of having infections. Edema can also aid in infections, since the exceeded amount of fluids would dissolve the matrix.

There are no main arteries or veins supplying the pulp, the vascular system within the pulp is composed of arterioles and venules; called the microcirculatory system.

Even though there are plenty of arterioles and venules, and the fact that the micro vascular system is accompanied by nerve fibers, but the amount of blood received is restricted since there’re no main arteries or veins. The body compensates this limit by acquiring a higher blood flow rate and blood pressure in the pulp than any other tissue in the body.

Types of cells in the pulp:

* Formative, Fibroblasts & odontoblasts
* Defensive, found in diseased pulp
* Progenitor cells, undifferentiated mesenchymal cells; used as stem cells in regeneration and revascularization. They can be used in treatment modalities because of their nature in forming other types of cells.

 The nerve fibers in the pulp are derived from the maxillary and mandibular division of the trigeminal nerve. The fibers enter through the apical foramen among with the blood vessels forming parallel bundles. They’ll be folded together by the connective tissue, forming neuro-vascular bundles. These bundles appear in 10-20% of the tubules in the coronal pulp, less than 1% around the region of the cemento-dentinal junction, and occasionally found in the radicular dentine. The nerve fibers penetrate into the dentine for a few micrometers only.

* This is because of the nature of the nerve cells found in the pulp, being ubiquitous; having the simplest structure of all nerves. Ubiquitous nerves can only sense pain, no matter what the causing stimuli was. These nerves are found in the cornea , eardrum and the dental pulp

They sense pain under high pressure and are classified in to 2 main categories:

* Alpha-Delta fibers, conduct rapid sensations of pain and are found in the peripheral zones of the pulp. To an extent, they release signal into the dentinal tubules.
* C-fibers, found deep in the pulp and exhibit sensations from dull & aching pain, they terminate in the pulp tissue as free nerve endings or branches around blood vessels.

80% of the nerves found in the pulp are C-fibers

The Alpha-Delta fibers have a low threshold of excitability since they’re peripheral, while the nociceptor C-fibers are more associated with pulpitis.

Nociceptor C-fibers: Pain conducting fibers that respond to stimuli capable of injuring tissues.

Because of the sparse cellular composition of the pulp, the rate of oxygen consumption is low in comparison to other body tissues. This is the reason why the pulp could still function well in an ischemic patient, or during physiological vasoconstriction.

Many of the most commonly used substances could suppress the activity of the pulp to a limit, such vasoconstrictors are:

* Eugenol - Silver Amalgam
* Calcium hydroxide - Local anesthetics

The application of orthodontic force to molars for 3 days also suppresses the activity of the pulp by 27% due to vasoconstriction, yet the pulp is able to withstand the force due to its ability in functioning at low oxygen levels. To conclude, the nerve fibers in the pulp can withstand necrosis.

There’s no or merely small sensation during vitality testing and reaching the Alpha-delta fibers. While during instrumentation, C-fibers are reached. Hence, pain is sensed.

C-fibers are less susceptible to hypoxia since neuro-vascular bundles’ characteristics aid in withstanding low oxygen levels.

Pain, is a complex phenomenon that has physiological and psychological components. These effects vary from one patient to another even if the stimuli were of the same force. Pain is caused by drugs, emotions, forces, and other outer or inner stimuli.

When a pain stimulus is applied, the neurons in the pulp transport the signal to the thalamus; where it’s perceived as pain. Then the signal’s carried to the cerebral cortex; where the processing occurs according to previous experiences.

Dental pain is pressure mediated, meaning that there’s a linear relationship between both variables. In addition to having a link with the heart beat rate, blood flow to & from the pulp, vasodilators and constrictors, and temperature fluctuations.

The mean pulp pressure is noted to be 30-35 mmHg, if the pressure is under or within the noted range; the response exerted is reversible and the nerves wouldn’t be damaged. On the contrary, if the pressure exceeded 35mmHg, the response would be irreversible. Hence, the nerves get damaged.

The cellular structures in the dentine have no or minor sensory function. Yet, the pulp gets the sensation from the stimuli. This is due to the hydrodynamic theory of Brannstrom. The rapid fluid movement in dentinal tubules, due to temperature based stimuli, is capable of generating energy which would allow the sensory neurons in the pulp-dentine junction to reach the threshold.

Heat causes vasodilation, therefore increasing the intra-pulpal pressure.

When heat is applied to an intact pulp, time is needed to feel the pain; a gradual sensation. Since the intra-pulpal pressure is rising from a normal range. Whereas if heat is applied to an inflamed pulp, pain would be felt immediately. This is because an inflamed pulp’s pressure would already be above the normal range, so any slight increment in the pressure; would make the pain sensation worse.

In contrast, applying a cold stimulus would generate an immediate pain sensation, even if the pulp was intact. The enamel contracts as soon as the stimuli is applied, allowing capillaries to exert a force against the dentinal tubules, this forms a flux in the fluid within the tubules. Hence, sensory neurons in the pulp are activated.

In regions where enamel would be absent, applying a cold stimulus would result in pain due to the direct activation of the sensory neurons. There’d be no enamel contraction and forces subjected against the tubules.

The pain resulting due to cold stimuli are quickly adapted to; pain would be sensed for a short period of time.

In advanced acute pulpitis; where necrosis occurs at varying degrees on the coronal part. Cold stimuli could be used to relieve the pain temporarily, since it would cause vasoconstriction; reversing the effect of necrosis. Hence, the intra-pulpal pressure would decrease.

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