

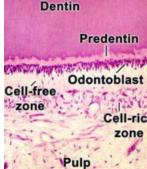
## ENDO 430 STUDY REVIEW

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# Intro to Endo

The Branch of dentistry concerned with the morphology, physiology, and pathology of the human dental pulp and peri radicular tissues

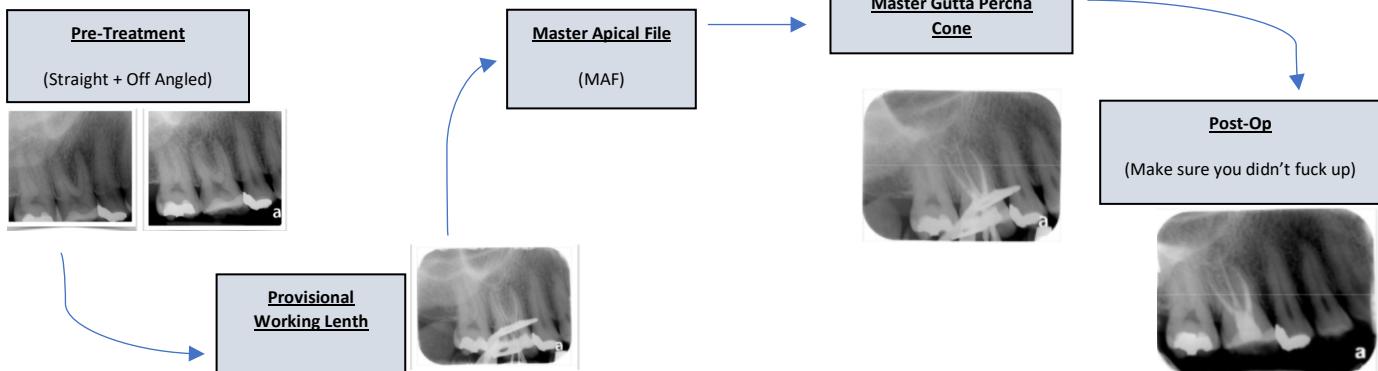
Functions of the Dental Pulp	
Nutrition	Blood supply for the tooth/dentin provided in the pulp
Sensory	Changes in temp, mechanical vibration, and chemical irritation sensed by the pulp
Formative	Involved in support, maintenance, and continued formation of dentin 
Defensive	Triggers inflammatory and immune response when needed
Protective	Development and formation of secondary + tertiary dentin to ↑ coverage of pulp -> Walls itself off
Contents of the Pulp	
Cells	Odontoblasts, Fibroblasts, WBC, Undifferentiated mesenchymal cells, Macrophages, Lymphocytes - NO fat cells
Fibrous Material	Reticular fibers and collagen fibers (Type I and Type III collagen)
Ground Substance	A medium to transport nutrients to cells and metabolites of the cells to the vessels for removal

Indications for Endo	<ul style="list-style-type: none"> <li>- Teeth displaying <b>pulpal and/or periradicular pathology</b> (unless it's reversible)</li> <li>- When tooth is restoratively hopeless and <b>SHOULD</b> be extracted, but cannot be for medical reasons (bisphosphonates etc)</li> <li>- Prophylactically to <b>avoid certain pulpal involvement</b> during crown fabrication</li> </ul>
Contraindications for Endo	<ul style="list-style-type: none"> <li>- <b>Non-restorable teeth</b> (Can't crown or restore? Extract)</li> <li>- <b>Inadequate periodontal support</b></li> <li>- <b>Vertical root fracture</b> (Root amputation, or RPD, FPD, Implant etc needed instead)</li> <li>- <b>Uncooperative Patients</b></li> <li>- <b>Poor oral condition</b> that cannot be improved within a reasonable period</li> <li>- <b>Non strategic tooth</b></li> </ul>

Ok....so you have deemed a tooth worthy of your Endo skills, now what do you do?

<u>Endo Sequence</u>
1. Pre-Procedure Radiograph
2. Access Cavity Preparation -> This is numero uno for importance, don't fuck this up or you will regret it for the foreseeable future
3. Working Length Determination
~ Trial File to Provisional working length (estimated on Radiograph) -> Take PWL Radiograph -> Move up 3 file sizes (Master Apical File)
4. Debridement
5. Cleaning and Shaping
~ Step Back 5 sizes (0.5mm back with each size)
~ Prepare Coronal ½ with Gates Glidden (3 sizes)
6. Take MAF Radiograph
7. Master Cone Fit (Gutta-percha) -> Place with Sealer and 1 Accessory Cone -> Master Cone Radiograph
8. Filling (Gutta-percha accessory cones + sealer)
9. Cleaning the pulp chamber -> Remove the excess gutta percha to below the CEJ (Keep the chamber clear) -> Post Op Radiograph
10. Temporary filling

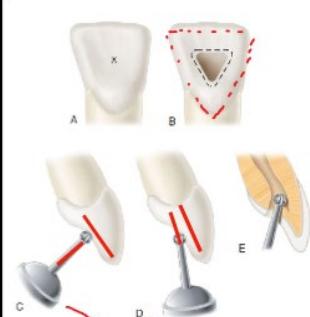
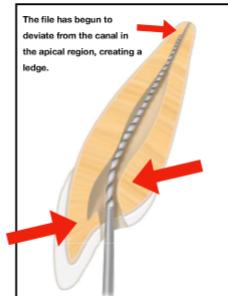
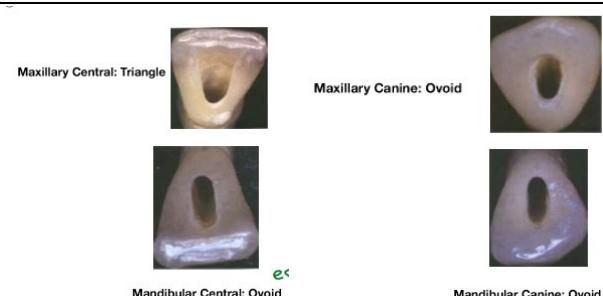
## Radiographic Sequence



## Access Cavity Prep

**\*\*One of the most important phases\*\***

- If you make the access too small = makes future you hate current you
- If you make access too large = Weakens tooth structure and makes future patient hate both current and future you

<b>Objectives</b>	<ul style="list-style-type: none"> <li>- Remove all caries present -&gt; Do this as much as possible before opening up the pulp chamber</li> <li>- Conserve sound tooth structure</li> <li>- Unroof the pulp chamber completely</li> <li>- Remove all coronal pulp tissue (necrotic or vital)</li> <li>- Locate all root canal orifices</li> <li>- Obtain straight line access to apical foramen (or initial curvature of the canal)</li> </ul>
<b>Anterior Access</b>	 <ol style="list-style-type: none"> <li>1. Direct bur 90 degrees to the clinical crown in the middle 3rd <ul style="list-style-type: none"> <li>- Can use FG carbide fissure bur or round bur</li> </ul> </li> <li>2. Once you reach the "drop" into the chamber, angulate bur almost parallel with the clinical crown</li> </ol> <p><b>Removing "Lip" on the roof of the canal</b></p> <ul style="list-style-type: none"> <li>- Place round bur on the inside of the catch and pull it out (when its on). Will remove the lip on the outstroke without risking gouging the opposite wall of the chamber</li> </ul> <p><b>Inadequate access preparation</b></p> <p>*Files should be able to remain vertical in the canal without bending on a lingual shoulder*</p> <p>The incisal extension is incomplete</p>  <p>lingual shoulder was not removed</p>
<b>DG16 Explorer</b>	 <p>Used to confirm pulp chamber and locate canals Verifies straight line access</p>
<b>Access shapes</b>	

### Criteria for a proper access cavity

- Sufficient amounts of the pulp chamber must be exposed (Including pulp horns)
- Must allow for the locating of all canal orifices
- Provides straight line access to mid/apical 3rd of canal (facilitates cleaning, shaping, obturation)
- Never results in unnecessary sacrifice of tooth structure

# Endo Dx

**There are 5 stages for making a good Dx:**

1. Pt tells you why they are looking for advice
2. Clinician questions Pt about S/S that led to visit (**Subjective**)
  - Chief Complaint
  - Med + Dent Hx
3. Clinician performs objective tests (**Objective**)
  - Clinical Examination
  - Clinical Testing
  - Radiographic analysis
  - Etc
4. Clinician correlates Objective + Subjective findings = Differential Dx
5. Formulate definitive Dx

<b>Tests Needed for Endo Dx</b>					
**Aim is to reproduce patient's C/C**					
<b>Med Hx</b>	<ul style="list-style-type: none"> <li>- Past/Recent Tx</li> <li>- Drugs</li> </ul>				
<b>Chief Complaint</b>	<ul style="list-style-type: none"> <li>- How long? Symptoms? Duration of pain? Location? Onset? Stimuli? Relief? Referred pain? Medications?</li> <li>- Recent Dental Tx</li> </ul>				
<b>Clinical Exam</b>	<ul style="list-style-type: none"> <li>- Facial Symmetry</li> <li>- Sinus Tract</li> <li>- Soft Tissue</li> <li>- Periodontal Status (Probing, Mobility)</li> <li>- Caries</li> <li>- Restorations (Defective? Newly Placed?)</li> </ul>				
<b>Clinical Tests</b>	<b>Pulp Tests</b> <p><u>Cold Test</u></p> <ul style="list-style-type: none"> <li>- Primary pulp testing method</li> <li>- Abnormal if: <b>No response</b>, or <b>lingering pain</b> (&gt;30sec) after stim. removal, <b>Immediate severe pain</b></li> </ul> <p><u>Heat Test</u></p> <ul style="list-style-type: none"> <li>- Mostly used to identify tooth that is hot sensitive to patient when they drink hot liquids (needs to be at least <b>47 degrees</b> to feel pain at pulp) -&gt; <b>Hot sensitive + cold relief = maybe necrotic tooth</b></li> </ul> <p><u>Electric Pulp Test</u></p> <ul style="list-style-type: none"> <li>- Doesn't indicate histologic health of pulp, only shows if there are some viable nerves or not                     <ul style="list-style-type: none"> <li>- If <b>no response</b>: <b>Pulp is necrotic</b></li> </ul> </li> <li>- No significance to the numbers alone, only if they differ significantly from the average measured</li> </ul> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #90EE90;"> <th style="text-align: center; padding: 2px;">False +'ve (+'ve = sensation/vitality)</th><th style="text-align: center; padding: 2px;">False -'ve (-'ve = no sensation/vitality)</th></tr> </thead> <tbody> <tr> <td style="padding: 2px;">Partial pulp necrosis (1 canal is vital but the rest is dead) High Pt anxiety Ineffective tooth isolation (sensation transferred to other vital teeth) Contact with metal resto's</td><td style="padding: 2px;">Calcified Canals Recent tooth trauma Immature apex Drugs causing ↑ pain threshold Poor contact with tester on tooth</td></tr> </tbody> </table>	False +'ve (+'ve = sensation/vitality)	False -'ve (-'ve = no sensation/vitality)	Partial pulp necrosis (1 canal is vital but the rest is dead) High Pt anxiety Ineffective tooth isolation (sensation transferred to other vital teeth) Contact with metal resto's	Calcified Canals Recent tooth trauma Immature apex Drugs causing ↑ pain threshold Poor contact with tester on tooth
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<b>Periapical Tests</b>	<p><u>Percussion</u></p> <ul style="list-style-type: none"> <li>- Percuss teeth (<b>vertically</b>) to identify the specific tooth causing pain on mastication (doesn't indicate vitality)</li> <li>- Indicates inflammation in periodontal ligament</li> </ul> <p><u>Palpation</u></p> <ul style="list-style-type: none"> <li>- Firm pressure applied to mucosa covering root apices -&gt; Looking for <b>soft tissue swelling or bony expansion and/or pain</b></li> <li>- May indicate active periradicular inflammation</li> </ul> <p><u>Tooth Slooth (Bite test)</u></p> <ul style="list-style-type: none"> <li>- Cracked tooth/Fractured cusp will have <b>pain on release</b> and from specific cusp</li> </ul>				
<b>Radiographs</b>	<ul style="list-style-type: none"> <li>- New PA's (At least 2)</li> <li>- New BW's</li> <li>- CBCT</li> </ul>				
<b>Additional Tests</b>	<ul style="list-style-type: none"> <li>- Transillumination</li> <li>- Selective anesthesia</li> <li>- Test Cavity</li> </ul>				

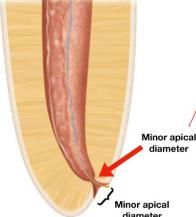
There are ALWAYS 2 different diagnoses -> Pulpal and Apical

Pulpal Diagnoses	
Normal	<ul style="list-style-type: none"> <li>- Symptom-free pulp</li> <li>- Responds normally to pulp testing</li> </ul> <p><u>Cold Test:</u> Mild/transient response 1-2 seconds after stim. removed  <u>Radiographs:</u> Normal!  <u>Pain:</u> Nothing  <u>Tx:</u> Nothing!</p>
Reversible Pulpitis	<p>Inflammation will resolve + Pulp becomes normal following management of etiology</p> <ul style="list-style-type: none"> <li>- Exposed Dentin</li> <li>- Dentinal Sensitivity (possibility from not using H<sub>2</sub>O during operative work)</li> <li>- Caries or Deep resto's</li> </ul> <p><u>Cold Test:</u> Discomfort/ Hypersensitive w/cold or sweet goes away 2 seconds/normal time following removal of stimulus  <u>Radiographs:</u> Normal  <u>Pain:</u> Non-spontaneous pain (only w/ repeatable stimulus -&gt; Cold or sweets etc)  <u>Tx:</u> Manage etiology (Sensodyne toothpaste, fillings etc)</p>
Symptomatic Irreversible Pulpitis	<p>Pulpal inflammation will not heal</p> <ul style="list-style-type: none"> <li>- Deep caries</li> <li>- Extensive resto's</li> <li>- Fractures exposing pulp</li> </ul> <p><u>Cold Test:</u> Sharp pain lingering &gt;30 seconds after stim removal  <u>Radiographs:</u> Possible deep caries, fractures  <u>Pain:</u> Spontaneous and referred pain (accentuated by postural change – lying down) -&gt; Wakes up at night  <u>Tx:</u> Root Canal Treatment (RCT)</p>
Asymptomatic Irreversible Pulpitis	<p>Pulpal inflammation will not heal</p> <ul style="list-style-type: none"> <li>- Likely Trauma</li> <li>- Deep Caries</li> <li>- Possible hyperplastic pulpitis (Pulp Polyp)</li> </ul> <p><u>Cold Test:</u> Normal response  <u>Radiographs:</u> Probably deep caries, signs of trauma  <u>Clinically:</u> Bleeds easily, probably can visually see the pulp, huge cavity  <u>Pain:</u> Mild pain while eating  <u>Tx:</u> RCT</p>
Pulp Necrosis	<p>Death of the pulp</p> <ul style="list-style-type: none"> <li>- Does not itself cause apical periodontitis UNLESS canal is infected</li> </ul> <p><u>Cold Test:</u> No Response</p> <ul style="list-style-type: none"> <li>- Might Respond to Heat and be relieved by cold = necrosis</li> </ul> <p><u>Pain:</u> Asymptomatic</p> <p><b>**Ensure this is not actually just a calcified canal (Hx of trauma)** -&gt; Would not need RCT in that case</b></p>
Previously Treated	<p>It is what it sounds like...Tooth has been endodontically treated and canals obturated w/ materials <u>other than</u> intra-canal medications</p> <ul style="list-style-type: none"> <li>- No response to Cold Test or EPT of course</li> </ul>
Previously Initiated	<p>Again pretty obvious...Partially treated (Pulpotomy or pulpectomy)</p> <ul style="list-style-type: none"> <li>- Tooth may or may not respond to pulp testing depending how far the previous Tx got</li> </ul>
Apical Diagnoses	
Normal	<p><u>Percussion:</u> No Pain  <u>Palpation:</u> No Pain  <u>Radiographs:</u> Lamina dura intact; PDL space uniform</p>
Symptomatic Apical Periodontitis	<p>Inflammation of the apical periodontium</p> <p><u>Percussion:</u> Painful  <u>Palpation:</u> Painful  <u>Radiographs:</u> Might not have any changes if it is early stages  <u>Tx:</u> If pain is severe -&gt; RCT</p>
Asymptomatic Apical Periodontitis	<p>Inflammation + Destruction of apical periodontium (pulpal origin)</p> <p><u>Percussion:</u> No Pain  <u>Palpation:</u> No Pain  <u>Radiographs:</u> Apical RL  <u>Tx:</u> RCT</p>
Acute Apical Abscess	<p>Inflammatory rxn to pulpal infection + Necrosis</p> <p><u>Pain:</u> Rapid onset, Spontaneous  <u>Percussion:</u> Painful  <u>Palpation:</u> Extreme tenderness  <u>Radiographs:</u> maybe no radiographic signs of destruction  <u>Clinically:</u> Pus formation and swelling, malaise, fever, lymphadenopathy -&gt; Non-draining swelling  <u>Tx:</u> Drain abscess, give antibiotics, RCT</p>

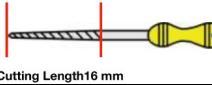
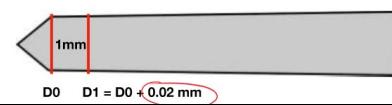
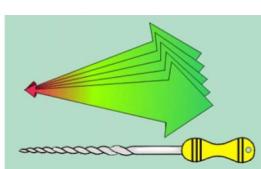
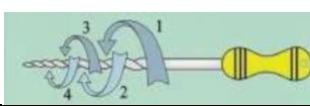
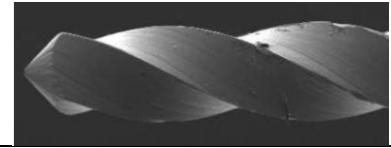
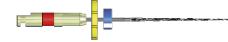
<b>Chronic Apical Abscess</b>	Inflammatory Rxn to pulpal infection and necrosis  <u>Pain:</u> Gradual onset, little or no pain <u>Percussion:</u> Little or no pain <u>Palpation:</u> Possible tenderness, evidence of sinus tract <u>Radiographs:</u> Typically find RL <u>Clinically:</u> Intermittent pus discharge -> Through Sinus Tract <u>Tx:</u> RCT  **Can place gutta percha cone through sinus tract and take x-ray to find the tooth source of infection**
<b>Condensing Osteitis</b>	Bony reaction to low-grade inflammatory stimulus at apex of the tooth  <u>Radiographs:</u> Diffuse RO lesion <u>Tx:</u> No Tx
<b>Other Periapical Diseases</b>	
<b>Apical Granuloma</b>	Triggered by bacteria (or just their toxic products) diffusing through apical foramen <ul style="list-style-type: none"> <li>- Response is chronic inflammation of periapical tissues and bony resorption -&gt; cavity formed around root tip is filled in with granulation tissue</li> </ul> <u>Tx:</u> RCT
<b>Radicular Cyst</b>	Rests of Malassez around the periapical area may proliferate and form a cystic cavity <ul style="list-style-type: none"> <li>- Cannot differentiate radiographically from Apical Granuloma</li> </ul> <u>Tx:</u> RCT -> if lesion keeps growing, we know it's a cyst = surgical excision

## Instrumentation

With proper access you can now determine your working length and begin cleaning and shaping the canals

<b>Working Length Determination</b>  	<ol style="list-style-type: none"> <li>1. Take a radiograph of the tooth</li> <li>2. Calibrate the measurement tool (Size 1 PSP is 40mm x 24mm)</li> <li>3. Radiographic Length: Measure the distance from the incisal edge of the tooth to the apical foramen</li> <li>4. Provisional Working Length (PWL) = Radiographic Length (RL) -1mm. <ul style="list-style-type: none"> <li>- The Apical constriction is typically 0.5-3mm short of the radiographic apex (average 1mm) this is why we -1mm from the RL.</li> </ul>  </li> <li>5. Adjust rubber stopper on Trial File to the PWL -&gt; Minimum size of #15 File (White)</li> <li>6. Insert trial file until you feel the tip engage (hopefully on the apical constriction)</li> <li>7. Take Trial File Radiograph <ul style="list-style-type: none"> <li>- If 1mm short of apex then you are good!</li> <li>- If &lt; or &gt;1mm short of PWL (but only by 0.5mm) then adjust 0.5mm and you are good. No need to take another TF radiograph</li> <li>- If &lt; or &gt; 1mm short (but more than 0.5mm) then adjust accordingly and take a new TF radiograph</li> </ul> </li> </ol> <p><b>What if you blow it and instrument short or beyond the apical constriction?</b></p> <ul style="list-style-type: none"> <li>- <b>Short</b> = Risk not removing all the infected tissue</li> <li>- <b>Beyond</b> = Lose apical seal for condensation, and risk forcing NaOCl through canal into tissues (VERY painful)</li> </ul>
<b>Debridement and Cleaning</b>	= Remove infected soft tissues and organic debris <ul style="list-style-type: none"> <li>- Vital and necrotic pulp</li> <li>- Inflammatory exudate (pus)</li> <li>- Biofilms and their products</li> <li>- Infected dentin</li> </ul>
<b>Shaping</b>	= Enlargement of root canal system to achieve apically tapered conical form <ul style="list-style-type: none"> <li>- Provides apical access for disinfecting irrigants</li> <li>- Creates space for medicament placement</li> <li>- Facilitates root canal obturation</li> </ul> <p>**Must maintain original pathway of the canal and retain the integrity of radicular structures**</p>

## Hand Files

<b>Lengths</b>	21mm 25mm 31mm  Cutting Length 16 mm																				
<b>ISO Files</b>	Standardized tapers! <ul style="list-style-type: none"> <li>↑ 0.02mm diameter for every 1mm from point 0 (D0)</li> <li>D16 = D0 + 0.32mm</li> </ul> 																				
<b>Uses</b>	<p><b>Reaming</b></p> <ul style="list-style-type: none"> <li>This is when you <b>twist</b> the file in the canal -&gt; like threading a screw</li> </ul>  <p><b>Filing</b></p> <ul style="list-style-type: none"> <li>Moving the <b>file up and down</b> without twisting</li> </ul>  <p><b>Balanced Force</b></p> <ul style="list-style-type: none"> <li>Twisting the file in -&gt; then while still applying pressure twist it the other way (breaks off dentin chunks)</li> <li>This way you don't just "unscrew" the file from the wall</li> </ul> 																				
<b>Types</b>	<p><b>Headstrom</b></p> <ul style="list-style-type: none"> <li>Used <b>for aggressively cleaning the canal</b></li> <li>Don't use reaming motion (can't rotate more than 30°)</li> <li>Responsible for most file fractures</li> </ul> 	<b>Reamer</b> 																			
<b>Color Code</b>	 <p>Ø ISO (Ring)  <table border="1"> <tr><td>6</td><td>8</td><td>10</td><td>15</td><td>20</td><td>25</td><td>30</td><td>35</td><td>40</td><td>45</td><td>50</td><td>55</td><td>60</td><td>70</td><td>80</td></tr> </table> </p> <p>Taper (SMD)  <table border="1"> <tr><td>.02</td><td>.04</td><td>.06</td><td>.08</td><td>.10</td></tr> </table> </p>	6	8	10	15	20	25	30	35	40	45	50	55	60	70	80	.02	.04	.06	.08	.10
6	8	10	15	20	25	30	35	40	45	50	55	60	70	80							
.02	.04	.06	.08	.10																	

### At UBC

Sizes 06-10, 60-140 = K Files (Stainless Steel)

15-25 = FlexSS K Files (Flexible stainless steel K Files)

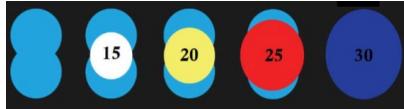
30-50 = Flex NiTi K Files (Flexible nickel titanium K Files)



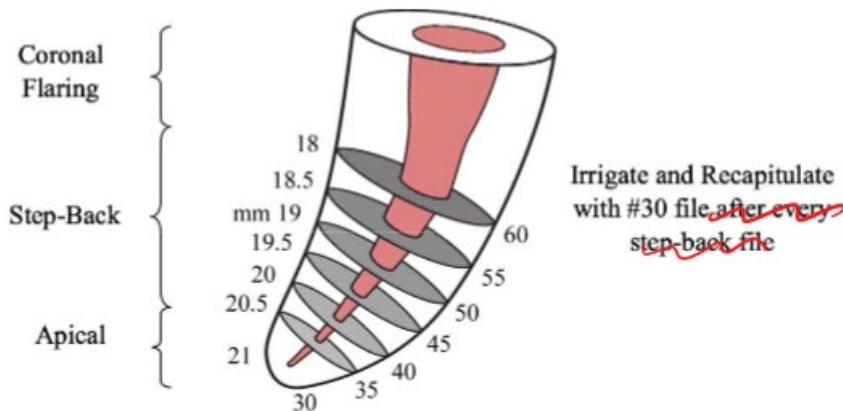
## Step-Back Technique

\*After every file: Rinse canal with NaOCl and clean file with alcohol on moist gauze\*\*

1. Obtain your working Length (Minimum File Size #15)
  - If #15 doesn't bind, then try #20 etc etc until you feel binding at WL
2. Sequentially instrument 3 sizes larger than your initial Trial File at working length
  - So if your trial file is #15. Do #20 - #25 - #30 -> #30 is now your Master Apical File



3. Use Gates Glidden Drills (#2, 3, 4) to **enlarge the coronal and middle 3rds of the roots** ( $\uparrow$  space to make your life easier)
  - Use #2, 3, 4, until you feel resistance to coronal 3<sup>rd</sup> of root
  - #1 = 0.2mm wide ; #6 = 1.5mm wide
4. **Step- Back:**
  - **Progressively instrument 0.5mm back while moving up 4-5 file sizes**
  - If WL is 20mm and MAF is #30 then -> #35 @19.5 - #40 @19mm - #45 @18.5mm - #50 @18mm - #55 @ 17.5mm
5. **Circumferential Filing** -> Complete the flare and blend the apical and coronal preparations
6. **Recapitulation** -> Return to WL with small #15 file to clean out any debris buildup at that apical seat



### Sodium Hypochlorite (NaOCl 0.5%-5.25%) is a great irrigant because:

- Antimicrobial
- Dissolves vital and necrotic pulpal tissues
- Dissolves the organic component of dentin
- Acts as a lubricant for the files

\*\*Important to not force the irrigant through the apical foramen -> Causes bruising and lots of pain

# Principles of Obturation

But first lets do a review

1. Take Initial Radiograph
2. Access
3. Canal Negotiation
  - To Apex using 08, 10, or 15 (Whichever binds) -> Trial file radiograph
  - Coronal Flaring: Rotary NiTi files or Gates Glidden burs
4. Working Length determination -> WL Radiograph
  - If need to adjust >1mm to be 1mm away from the apex then you need to take another radiograph
  - If the adjustment is <1mm then you don't need an additional radiograph
5. Canal Instrumentation
  - **Step Back Technique:**
    - o 3 instrument sizes beyond the first that binds at WL (Minimum size #30) -> Take Master Apical File Radiograph (MAF)
      - Recapitulate by returning to WL with #10 small file -> removes debris/dentin mud that blocks your full WL

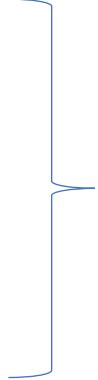
Dentin mud from not recapitulation.
    - o Step Back 0.5mm increments with 4-5 instruments sizing up
    - o Coronal Flare with GG burs
      - Use GG burs 2, 3, 4 progressively until you feel resistance (then move up 1 size)
    - o Balanced force filing, or circumferential filing in the middle and coronal 3rds to taper the coronal flare into the apical step backs
  - **Modified Step Back Technique:** -> Limit the risk of bacterial invasion of the periapical tissues
    - o Estimate the WL
    - o Instrument canal(s) w/ hand files up to Size #35 till Mid Root level
    - o Gates-Glidden burs (2, 3, 4,) to resistance until approx. mis root level
    - o Determine Working Length
    - o Instrument canals to MAF
    - o Perform Step-Back as usual
    - o Blend apical and middle thirds (circumferential filing, or balanced force)
  - **Crown-Down technique**
    - o NiTi Files and Hand files
    - o Start at the coronal portion and work your way to the apex -> In theory this ↓ the bacterial load for when you instrument the apex which ↓ risk of pushing bacteria through the other side
  - **Balanced Force technique**
    - o Used with NiTi hand files in curved canals
6. Obturation
  - Lateral Compaction
  - Vertical Compaction
  - Thermoplasticized Gutta-percha (single cone technique)
7. Coronal Restoration
  - Temp w/ appointment for permanent resto
  - Permanent filling
  - Cuspal coverage restoration

Definitions	
<b>Working Length (WL)</b>	- 1mm from the radiographic apex
<b>Master Apical File (MAF)</b>	- 3 instrument sizes above the 1 <sup>st</sup> instrument to bind at working length - Take a Master Apical File film after all instrumentation is done
<b>Master Cone (MC)</b>	- Gutta-Percha cone that conforms to the apical preparation - Trial Cone film = Radiograph with MC+1 accessory cone in the canal

## Apical Preparations

<b>Apical Stop</b>	Instrumentation blocked short of ideal WL <ul style="list-style-type: none"> <li>- <b>Intentionally creates a blockage at WL</b></li> </ul>
<b>Apical Seat</b>	Result of Step-back preparation <ul style="list-style-type: none"> <li>- <b>Nicely tapered to the constriction</b></li> </ul>
<b>Open Apex</b>	Over instrumentation through the apical foramen <ul style="list-style-type: none"> <li>- <b>NOT GOOD</b></li> </ul> <p><b>Now what?</b></p> <ul style="list-style-type: none"> <li>- Can take new WL film with a large file that binds at WL</li> <li>- Create an apical stop or seat (if open apex is WAY open though then you would have to remove too much structure) -&gt; OR you can fill the end with Biodentin or MTA to plug the hole</li> </ul>  <div style="display: flex; justify-content: space-around;"> <span>Apical stop</span> <span>Apical seat</span> <span>Open apex</span> </div>

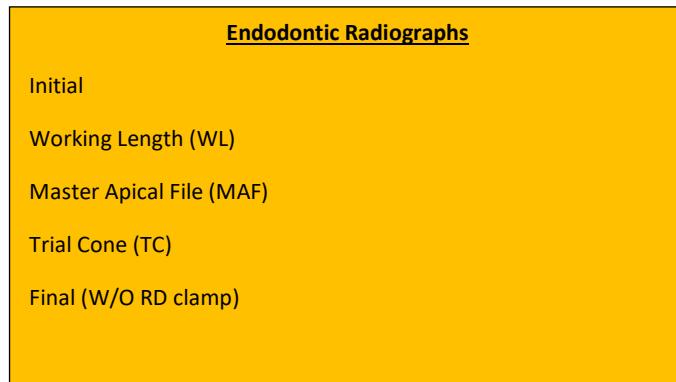
## Obturation

<b>Ideal Properties of Obturation Materials:</b> <ul style="list-style-type: none"> <li>Seals canal (Apically + Laterally)</li> <li>Bactericidal or <b>Bacteriostatic</b></li> <li>Non irritating to Periapical tissues</li> <li>Impervious to moisture</li> <li>Sterile and easily disinfected</li> <li>Easy to place in canal</li> <li>Radiopaque</li> <li>Non-staining to tooth structure</li> <li>Non-shrinking after placement</li> <li>Easily removed from canal</li> </ul>	 <p>Long live Gutta-Percha (which is only 20% GP and 75% ZOE)</p>
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Techniques	
<b>Lateral Compaction</b> <ul style="list-style-type: none"> <li>- Cold Cones</li> <li>- Solvent softened custom cones (Formed Cone Technique)</li> </ul>	<p><b>Steps:</b></p> <ol style="list-style-type: none"> <li><b>Irrigation:</b> <ul style="list-style-type: none"> <li>- Rinse with NaOCl and EDTA -&gt; leave for 3 mins to dissolve smear layer</li> <li>- OR rinse with Qmix</li> </ul> </li> <li><b>Dry canal with measured paper points</b> <ul style="list-style-type: none"> <li>- If they are too long (and you don't trim that shit) it can irritate the periapical tissues -&gt; Causes bleeding, which slows the appointment down while you manage that</li> <li>- Come in Fine, Medium, Coarse, Extra coarse</li> </ul> </li> <li><b>Fit and form a Master Cone</b> <ul style="list-style-type: none"> <li>- Choose the appropriate size of GP cone (Standardized cones come in the same tapers as the files, or Non-standardized cones need to be trimmed)</li> <li>- <b>The proper cone will feel "tug-back" 1mm from the WL</b></li> <li>- Dip in chloroform for 1-2seconds -&gt; insert into canal and tamp in and out a few times</li> <li>- Check MC for the correct length and apical impression</li> <li>- Take Radiograph to confirm?</li> </ul> </li> <li><b>Add sealer to canal</b> <ul style="list-style-type: none"> <li>- Use file size 1 smaller than MAF (or coat a finger spreader) -&gt; coat 1/3 with sealer</li> <li>- Place file in canal and spin counter clockwise</li> </ul> </li> </ol>

	<p>5. Add <b>sealer to Master Cone and insert</b>        - Coat only apical end of MC -&gt; insert in the same orientation as it was formed</p> <p>6. Insert Spreader to apical 3<sup>rd</sup> of the root (D11T, or D11)        - <b>Should reach 1-2mm from WL</b>, or to the level of the formed cone impression        - Rotate the spreader back and forth to condense the MC laterally</p> <p>7. Add <b>Accessory Cone</b>        - Remove spreader, add 1 accessory cone (make sure it is smaller than spreader diameter) with sealer at the apical end</p> <p>8. Take <b>Trial Cone Radiograph</b>        - Ensure GP is to full WL and there are no voids in the apical 3<sup>rd</sup></p> <p>9. Add more accessory cones until you are about 4mm apical of the CEJ</p> <p>10. Burn off GP from orifice (at height of CEJ) and condense        - Heat Glick and seal off GP at orifice (or use a Touch and Heat unit)        - Cold condense with a vertical plunger        - If above the CEJ it will appear as discoloration in the tooth and ↓ esthetics.</p> <p>11. Restore Access Cavity        - Fill chamber with cotton pellet + Temp filling (Cavit, IRM)        - Permanent resto; post/core buildup</p>
<b>Vertical Compaction</b>	
<b>Thermoplasticized Injection</b> - Obtura - Hygenic - Calamus	
<b>Gutta Percha Carrier systems</b> - Therafil - Densfil - Gutta Core	 <p>This is the shit right here -&gt; Gutta Core        - Same gutta-percha but with ↑ flexible strength        - Shape is retained when it is heated        - Grey Radiopacifiers are added for ↑ radiographic appearance</p> <p>-&gt; Centrally condenses the surrounding flowable GP        - Removed with ease        - Flowable warm GP can move in 3 dimensions to the apex</p>

<b>Temporary Filling Materials</b>	<p>**If you are only doing a <b>temp</b>, place a cotton pellet in the chamber first to protect your nice endo.        Makes it easy to know how deep to drill when you are removing the temporary material**</p> <p>Cavit</p> <ul style="list-style-type: none"> <li>↑ Sealing but ↓ compressive strength = mx it with other things like GIC or Composite to improve its properties</li> </ul> <p>IRM        Amalgam        Composite        GIC        Combinations -&gt; This is your Cavit + GI combo</p>
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## Treating Premolars

For multirooted teeth:

- Check for 2 PDL outlines
- 99.9% of the time the canal closest to the edge of the film is the buccal canal

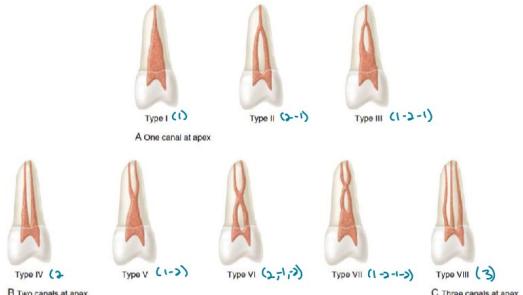


### Premolar Teeth

<b>Maxillary 1<sup>st</sup></b>	<b>Roots: 2</b> <ul style="list-style-type: none"> <li>- Roots typically have M and D concavity -&gt; Easy to perf! Tread lightly sweet prince, don't create a round canal system, follow the hour glass or figure 8 shape</li> <li>- 1 of the roots is usually shorter</li> <li>- Palatal root tip can have a buccal curvature; Buccal root tip can have a palatal curvature</li> </ul> <b>Canals: 2</b> <ul style="list-style-type: none"> <li>- Treat the easiest canal first -&gt; Palatal, then buccal</li> <li>- Act as though there are 2 canals if there is a sketchy furcation -&gt; Instrument the L and the B walls more than the walls at the center of the tooth</li> </ul> <p>**possible to have 1 root with 2 canals, or rarely (&lt;2%) 3 roots with 3 canals**</p>		
<b>Maxillary 2<sup>nd</sup></b>	<b>Roots: 1</b> <ul style="list-style-type: none"> <li>- Bayonet shaped root</li> </ul> <b>Canals: 1 or 2</b> <ul style="list-style-type: none"> <li>- If 2 canals they are typically closer together vs the 2 canals of the 1<sup>st</sup> premolar</li> </ul>		
<b>Mandibular Premolars (1<sup>st</sup> and 2<sup>nd</sup>)</b>	<p>Roots: 1 (occasionally 2)</p> <p>Canals: 1 (70%) or 2 (30%)</p> <ul style="list-style-type: none"> <li>- 2<sup>nd</sup> canal found towards the lingual (if it exists)</li> </ul> <p>**If you see a canal suddenly stop short of the apex -&gt; means it has split into 2**</p> <p><i>Frequently the canals will diverge in an "h" pattern, mid root length...how do we navigate through the lateral connection?</i></p> <ul style="list-style-type: none"> <li>- Curve the file so the tip runs down the lingual wall</li> <li>- Feel for a catch from the tip</li> <li>- File a bunch (small motions) to extend the lingual wall over the horizontal canal until it opens up direct access to the 2<sup>nd</sup> canal</li> </ul> <p>**DO NOT REMOVE THE FILE OR YOU MAY NEVER FIND THE 2<sup>ND</sup> CANAL AGAIN**</p>		

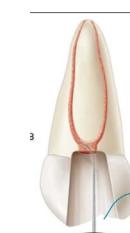
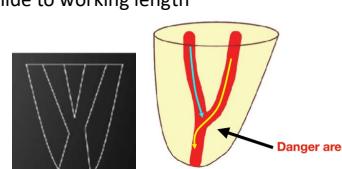
<b>Access Opening</b>	<b>Oval Shape</b> (in the B-L direction) <ul style="list-style-type: none"> <li>- Unroof the chamber</li> <li>- Gently now, remove the pulp horns</li> <li>- Obtain straight line access</li> <li>- Don't want to cut the floor of the pulp chamber -&gt; the furcation might be right under there and we don't want to have a sketchy perf</li> </ul>	
<b>Working Length</b>	For multi rooted teeth it's important to take an off angled film <ul style="list-style-type: none"> <li>- Use hand files of different sizes to differentiate the Buccal and Palatal canals (Make sure they bind though or the might fall out when the patient is moving to and from the Rad Room)</li> <li>- Before you run away to expose the images, remove the files from the tooth (and re-measure) -&gt; if you don't, risk the patient biting down on them and blowing through the apex, or them falling out</li> <li>- Make sure you maintain the same reference point when measuring (makes sense) also make sure you view your measured file from the same perspective as well for consistency.</li> </ul> <p>Take the WL and MAF films with 2 files in the tooth!</p> <ul style="list-style-type: none"> <li>- But instrument one canal at a time.</li> </ul>	
<b>Obturation</b>	Do 1 canal at a time <ul style="list-style-type: none"> <li>- Obturate the longer canal first and then the shorter canal after</li> </ul>	

## Pulp Space Configurations

Pulp Space Configurations		
Type I (1)		Single canal from pulp chamber to apex
Type II (2-1)		2 Separate canals leave pulp chamber, but join just above the apex to form 1
Type III (1-2-1)		1 Canal leaves the chamber and splits into 2 -> Then merge back into 1 canal
Type IV (2)		2 separate canals extend from chamber to apex
Type V (1-2)		One canal leaves chamber -> Splits into 2 just above the apex
Type VI (2-1-2)		2 canals leave chamber -> Merge into 1 in the body of the root -> Split again just above the apex
Type VII (1-2-1-2)		1 Canal leaves chamber -> splits into two -> Merges again in body of the root -> splits AGAIN above the apex of the root
Type VIII (3)		3 separate canals from chamber to the apex
		Exits apex as 3 canals
Vertucci1974		Gulabivala et al 2001

## Instrumentation and Obturation of Multi-Rooted Teeth

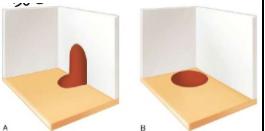
<b>Access Cavity</b>	<ol style="list-style-type: none"> <li>1. Must ensure proper isolation (Rubber Dam)</li> <li>2. <b>Control/Remove the caries</b> -&gt; Can't have bacteria contaminating the canal system <ul style="list-style-type: none"> <li>- If there is insufficient tooth structure after the caries control, <b>create a build up</b> -&gt; This helps with rubber dam stability and acts as a reservoir for the irrigant bleach (can't have it leaking everywhere...its bleach)</li> <li>- Buildup can be GIC, Composite, Amalgam</li> </ul> </li> <li>3. <b>Target the largest canal until you feel a drop</b></li> <li>4. Take Non-end cutting Endo "Z" bur (Gold shank) and unroof the rest of the chamber <ul style="list-style-type: none"> <li>- This bur helps to ensure we don't perf through the floor of the chamber</li> </ul> </li> </ol>	 
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	<b>Tooth</b>	<b>Sequence to attack the canals</b>
	<b>Mand. Anteriors</b>	Facial -> Lingual
	<b>Mand. Premolars</b>	Buccal -> Lingual -> Ribbon canals (extras) - Sometimes might be "h" shaped
	<b>Mand. Molars</b>	Distal (DB -> DL) -> Mesial (MB -> ML)
	<b>Max. Premolars</b>	Palatal -> Buccal (MB -> DB)
	<b>Max. Molars</b>	Palatal -> Buccal (DB -> MB1 -> MB2)
<b>Instrumentation</b>	<ul style="list-style-type: none"> <li>- Start with SS/NiTi Hand K-files</li> <li>- Finish instrumenting one canal at a time before moving to the next (this avoids confusions)</li> <li>- Provisional Working length film, taken with minimum #15 file (ideally different sizes in the same root or different types of files so you can differentiate)</li> </ul> <p><b>Explore the oval orifice with a curved file</b></p> <ul style="list-style-type: none"> <li>- Place tip in the orifice with the curve pointed to the buccal and then to the palatal to find the 2 respective canals</li> </ul> <p><b>2 Canals joining apically?</b></p> <ul style="list-style-type: none"> <li>- Identify this BEFORE the canals are completely instrumented to avoid breakage issues</li> <li>- When you place 1 file it will go to working length, but the second file in the other canal will come short -&gt; Now remove the first file, and the 2<sup>nd</sup> file will be able to slide to working length (this is how you know they connect)</li> <li>- Instrument 1 fully to working length, but the 2<sup>nd</sup> only to the "working length" of where they join...otherwise you will create an hourglass prep with no apical seat</li> </ul>	 
<b>Obturation</b>	<p><b>Obturate each canal separately</b></p> <ul style="list-style-type: none"> <li>- Take Master Cone Radiographs once you have placed as many MC+1 Accessory Cone's as you can (usually only 2 canals at a time though)</li> <li>- If there are more canals, take the Trial Cone Radiograph of the 1<sup>st</sup> 2 -&gt; If its good then burn off the MC and accessory at the orifice (don't finish those) -&gt; Take more trial cone radiographs of the other canals -&gt; NOW you can finish off compacting etc all of the other canals</li> </ul> <p><b>What if 2 canals branch within a common orifice lower down?</b></p> <ul style="list-style-type: none"> <li>- Might be hard to separately obturate 2 canals within the root without blocking 1 of them (lack of space in the coronal 3<sup>rd</sup>) -&gt; In this case you might need to open it up more in the B-L direction OR</li> <li>- Fit 1 formed MC into 1 of the canals (Larger and longer one) -&gt; Sear off the coronal excess -&gt; Gently push this cone away from the 2<sup>nd</sup> canal -&gt; Fit another formed MC cone into the 2<sup>nd</sup> canal -&gt; IF there is space, add accessory cones -&gt; Take trial Cone Film</li> </ul>	

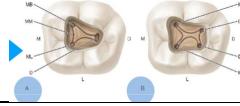
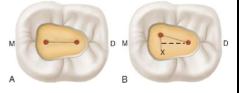
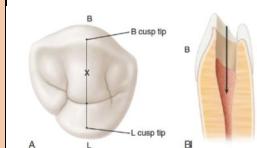
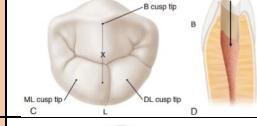
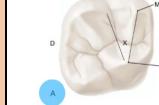
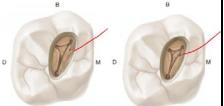
## Laws of Pulp Chamber Anatomy and Symmetry

These laws help us position the access and find the orifices

<b>Rules to Live By</b>		
<b>Law of Root Canal Centrality</b>		= The root canal space is located at the center of the tooth at the level of the CEJ
<b>Law of Root Canal Concentricity</b>		= The walls of the pulp chamber are concentric/Equidistant to the external outline of the tooth (at the level of the CEJ) <ul style="list-style-type: none"> <li>- Helps us estimate the location and size of the root canal access (Teeth that narrow externally will have narrow root canal)</li> </ul>
<b>Law of Dentin Color Change</b>		= The color of the dentin closest to the pulp chamber is always darker than the surrounding dentin (usually greyer)
<b>Law of Symmetry 1</b>		= In all teeth (not Max. molars though), the orifices of root canals are equidistant from a line drawn in the M-D direction through the center of the chamber floor

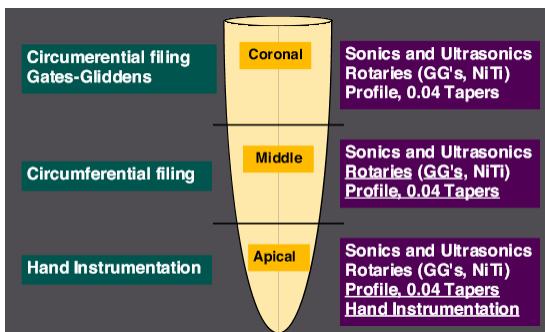
<b>Law of Symmetry 2</b>	= In all teeth (except Max. molars) the orifices lie on a line perpendicular to a line drawn in the M-D direction	
<b>Law of orifice location 1</b>	= The orifices of the root canal are always at the junction of the walls and the floor	
<b>Law of orifice location 2:</b>	<p>= The orifices are located at the vertices of the floor-wall junction</p> <ul style="list-style-type: none"> <li>- Make sure after your access the orifice is completely on the pulpal floor and not extending into the axial wall -&gt; Risk file breakage</li> </ul>	

## Access in Posterior Teeth

<b>Mandibular 1<sup>st</sup> Molar</b>	Access starts in central groove between <b>MB and ML</b> cusps	
	Can have 3 or 4 orifices (slightly different access shapes)	
<b>Mandibular 2<sup>nd</sup> Molar</b>	2 Canals -> Both orifices are along the M-D midline <ul style="list-style-type: none"> <li>- If the 2 are not in direct line with each other, there is probably a 3<sup>rd</sup> (tricky bastard) -&gt; Look for it just B to the M orifice (Area X below)</li> </ul>	
<b>Mandibular 1<sup>st</sup> Premolar</b>	Start the access about ½ way along the B cuspal ridge -> open into an oval shape	
<b>Mandibular 2<sup>nd</sup> Premolar</b>	Start Access slightly up the B cuspal ridge (almost in the central groove)	
<b>Maxillary 1<sup>st</sup> Molar</b>	Access in the central groove between the <b>MB and ML</b> cusps (x)	
	<b>The Elusive MB2 Orifice:</b> <ul style="list-style-type: none"> <li>- Typical in 2 locations: Along a direct line connecting MB1 and the Palatal Cusp, OR Just mesial to that line</li> <li>- If you cannot find it, tell the patient you are going to refer them to a specialist to find it (it's up to them to go or not, but this saves your ass in the case of recurrent endo issues because you didn't clean MB2)</li> </ul>	
<b>Maxillary 2<sup>nd</sup> Molar</b>	Can have 2 or 3 Orifices	
<b>Strange C-shaped Canal Anatomy</b>	Mandibular 2 <sup>nd</sup> Molar      Maxillary 1 <sup>st</sup> Molar	

# Rotary and NiTi Files

Hand Filing Technique I Rotary Technique

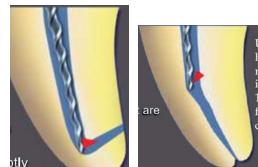


## Nickel Titanium

<b>Properties</b>	<p><b>Flexibility:</b> ↑ than SS  <b>Strength:</b> ↑ than SS  <b>Other nice features:</b> Shape Memory, Anticorrosive, No weakening after sterilization (unlike stainless)</p> <p><b>Exists in 2 diff. temps:</b></p> <ul style="list-style-type: none"> <li>- Martensite (Low temp) -&gt; Provides shape memory, elasticity and soft, ductile nature</li> <li>- Austenite (High Temp) -&gt; ↑ Strength, and hardness</li> </ul> <p><b>Shape Memory:</b> The ability of a deformation to be held, but then upon heating transform back to its original shape</p> <ul style="list-style-type: none"> <li>- At room temperature the NiTi stays in its Martensite form and will deform. But with heat it will “un-deform” into the Austenite Phase. Upon cooling again it will enter the Martensite deformable phase</li> </ul>
	<p><a href="https://www.slideshare.net/shadanAltayar/niti-in-endodontics-75307318">https://www.slideshare.net/shadanAltayar/niti-in-endodontics-75307318</a></p> <p><b>Resistance to Fracture by Twisting:</b></p> <ul style="list-style-type: none"> <li>= Maximum flexure before breakage <ul style="list-style-type: none"> <li>- SS &gt; NiTi -&gt; But both are legit according to the ADA</li> <li>- NiTi = Low torque instruments, passive!</li> <li>- SS = High torque instrument</li> </ul> </li> </ul>
<b>Recommended RPM's</b>	<p><b>ProFile:</b> 300RPM  <b>ProFile Vortex/Vortex Blue:</b> 500RPM</p>
<b>Engines for Rotary</b>	<p>Air Rotor MM324 -&gt; Variable Speeds  Electric (Aseptico): Different torque control, will automatically reverse if torque exceeds the level you set it to  (XSmart Easy): Cordless electric handpiece  (Promark Electric)</p>

<b>Files</b>	<p><b>Profile 0.04 Tapering:</b></p> <p>Step 1 Step 2 Step 3 Step 4 Step 5 Step 6 Step 7 Step 8 30/0.06 50/0.07 40/0.06 40/0.04 35/0.04 30/0.04 25/0.04 20/0.04 19mm 19mm 19mm 19mm 19mm 19mm 19mm 19mm</p>	<p>Orifice Shapers      Profile 0.04 Tapers 30 50 40 40 35 30 25 20 Crown Down to Apex Pre-clinical rotary NiTi setup</p>
	<p><b>U-Blade File -&gt; ProFile instrument</b></p> <p>Passive cutting action</p> <p>flat so it doesn't gouge opens side of walls</p>	<p><b>K-Blade File -&gt; Similar to ProTaper</b></p> <p>More active cutting with its sharper edges</p>
	<p><b>ProTaper SX file:</b></p> <ul style="list-style-type: none"> <li>- Variable taper</li> <li>- Does what the Gates Glidden burs do</li> <li>- This is useful for performing your <b>coronal enlargement</b>. The tip is really skinny so it doesn't widen your canal too much while the "heel" of the file will open up the coronal 1/3<sup>rd</sup> to make your life easy</li> </ul>	
	<p><b>Vortex/Vortex Blue Files:</b></p> <ul style="list-style-type: none"> <li>- <b>0.04 Constant tapering</b> (like the hand files – constant taper) -&gt; 0.06 taper also</li> <li>- ISO colors and tapers</li> <li>- <b>16mm working length</b></li> <li>- These are what you will use to instrument the canals</li> <li>- Safe End tip</li> </ul> <p>Standard "super elastic" NiTi reverts to its original straight position -&gt; Bounces back...this can cause the file to remove more dentin on the outside of a curve as it tries to straighten out</p> <ul style="list-style-type: none"> <li>- <b>Vortex Blue has ↓ shape memory = it holds its curvature 😊</b></li> </ul> <p><a href="https://www.youtube.com/watch?v=oO_gHQeebl">https://www.youtube.com/watch?v=oO_gHQeebl</a></p>	
<p><b>Stresses to NiTi</b></p>	<p><b>Torque Fatigue:</b></p> <ul style="list-style-type: none"> <li>- Electric motors have torque control</li> <li>- Air-Rotor have no torque control -&gt; DANGER</li> <li>- Occurs when <b>instrument tip is locked</b> (you pushed it in actively) and the shank continues to rotate</li> </ul> <p><b>Cyclic Fatigue:</b></p> <ul style="list-style-type: none"> <li>- Instrument stress around a curve -&gt; Produces compression on the inside and tension on the outside</li> </ul>	
	<p><b>**Don't Force Files**</b></p> <ul style="list-style-type: none"> <li>- Don't leave files in the tooth rotating -&gt; Always be moving it up or down</li> <li>- Don't let debris build up</li> </ul> <p><b>Helical Angles</b></p> <p>= Angle that the cutting edge makes with the long axis of the file</p> <ul style="list-style-type: none"> <li>- Constant helical angles allow debris to accumulate and are more susceptible to "screwing in" forces</li> <li>- Varying the helical angle avoids the above issues 😊</li> </ul> <p>Lower Helical angle (↓ flutes) = ↑ Efficiency Higher Helical angle (↑ flutes) = ↑ flexibility – Usually at the tip</p>	

<b>Cautions</b>	<p><b><u>Two canals that join:</u></b></p> <ul style="list-style-type: none"> <li>- Instrument the easier 1 to working length. -&gt; Then instrument the other to the length that they connect (Determined when you place two files in at the same time)</li> <li>OR</li> <li>- Instrument below where canals join w/ hand files</li> </ul> <p><b><u>Canal with intense double curve (J)</u></b></p> <ul style="list-style-type: none"> <li>- Use rotary short of the curve -&gt; Finish the J hook with SS files only up to #20</li> </ul> <p><b><u>Overuse of files</u></b></p> <ul style="list-style-type: none"> <li>- &gt;3 times ↑↑ the breakage risk. Use only once really</li> </ul> <p><b><u>Over-instrumentation at the apical foramen</u></b></p> <p><b><u>Ledges in Canal</u></b></p> <ul style="list-style-type: none"> <li>- Rotaries cannot advance further into canal and will not go to WL = ledge 😞</li> <li>- Use small curved hand files to negotiate ledges</li> </ul> <p><b><u>Abrupt curvatures</u></b></p> <ul style="list-style-type: none"> <li>- Rotaries won't advance around a sharp curve</li> </ul>
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#### **Steps in Rotary Instrumentation (ProFile Vortex Blue)**

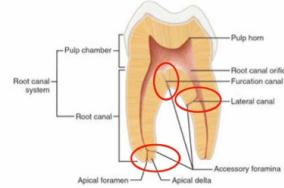
1. Estimate WL from Initial Film (Must be >20mm)
2. Coronal Flaring -> **Protaper SX File (300 RPM)**, providing a size 20 hand file goes passively to 18mm
  - Irrigant/Lubricant into the canal
  - Smooth insertion of SX file 1-2mm into canal -> Back out 0.5mm -> Into canal to resistance -> Remove SX, clean and irrigate
  - Recapitulate with hand file
  - Continue until in about middle 3<sup>rd</sup> of the root
3. Working Length Determination + WL Film -> **Hand File, min #15**
4. **Hand File to size up to #20 at WL**; Establish a glide path for the Rotary files
5. **Crown Down Technique**
  - Vortex Blue 40 -> 35 -> 30 -> 25 -> 20: Each to resistance, remove file, irrigate and clean, repeat. Stop when at WL or size 20 file at resistance
6. Hand file at WL to enlarge apex to Size 30
7. EDTA rinse after instrumentation
8. Dry Canals with Paper points

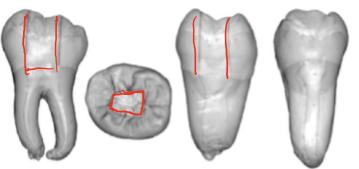
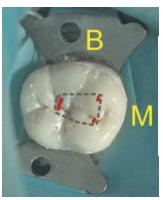
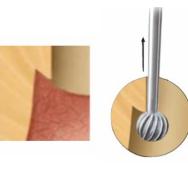
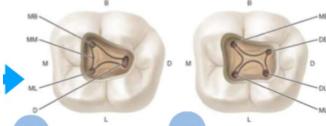
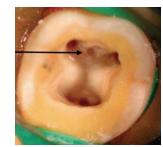


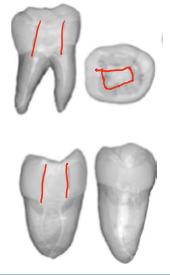
# Endo on Mandibular Molars

Many accessory foramina are found in the furcation

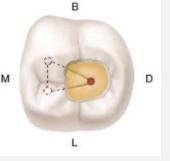
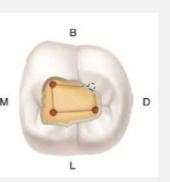
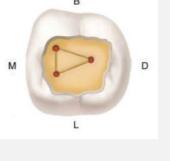
- Impossible to clean and instrument -> use NaOCl to dissolve the tissue and disinfect (important that the chamber floor is exposed to the irrigants)
- When finished the endo, seal the chamber floor w/ etch, bond, and flow composite over the orifices to prevent leakage into these foramina



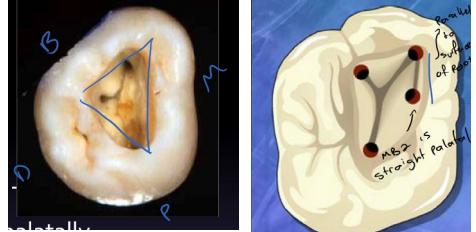
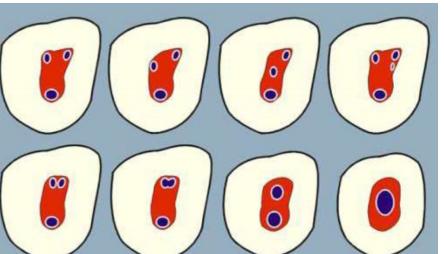
Mandibular 1 <sup>st</sup> Molar	
	Frequently Endo involved -> 1 <sup>st</sup> to erupt, most likely to need resto
<b>Roots:</b> <ul style="list-style-type: none"> <li>- Usually 2, sometimes 3</li> <li>- <b>Mesial root:</b> 2 canals under B and L cusps           <ul style="list-style-type: none"> <li>- Mesial Canals usually curved</li> </ul> </li> <li>- <b>Distal Root:</b> 1 or 2 canals           <ul style="list-style-type: none"> <li>- Could be 1 broad orifice splitting into 2 canals</li> <li>- Could be a B and a L</li> </ul> </li> </ul>	
	
<b>Canals:</b> 60% = 4 canals 39% = 3 canals <5% = 3 Mesial canals	
<b>Accessory Canals occur in 3 distinct patterns in 1<sup>st</sup> molars</b>	
<b>A</b>	Single furcation canal extends into intraradicular area <ul style="list-style-type: none"> <li>- 13% of the time</li> </ul>
<b>B</b>	Lateral canal extends from coronal 3rd of major canal into the furcation <ul style="list-style-type: none"> <li>- 23% of the time</li> </ul>
<b>C</b>	Both lateral and furcation canals <ul style="list-style-type: none"> <li>- 10% of the time</li> </ul>
<b>Access:</b> *Begin with <b>Triangular Access</b> w/ apex towards the D and base opening up over the MB ML*	
<ul style="list-style-type: none"> <li>- If a distal orifice is not centered B-L then open up the distal to a rectangular access</li> </ul>	
	
<i>Don't forget to remove the lip!</i>	
<b>Having trouble finding the location of calcified canal orifices?</b> <ul style="list-style-type: none"> <li>- Place NaOCl in the chamber and look for air bubbles to come up -&gt; This is the location of your orifice</li> </ul>	
Create a nice straight line access to make your life easy, if you use an <b>orifice opener</b> insert it into the canal and straighten it out (as per below)	
	
<b>Common Access Cavities:</b>	
	
**Always look for the Mid Mesial canal -> Clean out groove with LN bur**	
	

<b>Mandibular 2<sup>nd</sup> Molar</b> 	<p>A bit smaller coronally and is more symmetric</p> <ul style="list-style-type: none"> <li>- 2 roots often sweep distally in a gradual curve and apices are close together</li> </ul> <p>Most likely molar to suffer from crown-root fracture from extending over D marginal ridge</p> <ul style="list-style-type: none"> <li>- Full coverage resto indicated</li> </ul> <p><b>Canals:</b></p> <p>40% = 4 Canals 60% = 3 Canals</p> <p>*Most likely to have fused canals and C-shaped canals</p> <p><b>Access:</b></p> <p>Typically a triangular access form</p> <ul style="list-style-type: none"> <li>- Access in the mesial aspect, extend distally up to 1mm beyond the central groove</li> </ul> <p><u>Pay attention to the shape of the D orifice</u></p> <ul style="list-style-type: none"> <li>- Ovoid could indicate a double canal or ribbon shape</li> <li>- 2 canals in D root is less common than 1<sup>st</sup> molar, more likely to be C-shaped</li> </ul> 
<b>Mandibular 3<sup>rd</sup> molar</b>	High anatomic variation <ul style="list-style-type: none"> <li>- Roots often fused, short, curved, malformed, and generally bad for your endo</li> </ul>

## Issues with Mandibular Molar Access

	Inadequate Mesial extension and poor access placement		Failure to remove the roof of the pulp chamber <ul style="list-style-type: none"> <li>- BW's are good ways to judge your vertical depth</li> </ul> <p>Look for grey pulp floor, and developmental grooves to know you are deep enough</p>
	Inadequate extension of the distal access -> DB canal is unexposed <ul style="list-style-type: none"> <li>- Trace developmental grooves to their termination</li> </ul>		Perf! <ul style="list-style-type: none"> <li>- Measure the location on radiographs carefully</li> </ul> <p>Check the alignment of the tooth with probe first! Mesial perforations can be caused if you go straight down but the tooth is tipped</p>
	Overextension of the access -> Weakens tooth structure and compromises the final resto		
	Debris from a filling you accessed through blocking the canal orifices <ul style="list-style-type: none"> <li>- Completely remove the resto and irrigate lots to prevent this</li> </ul>		

# Maxillary Molars

<b>Anatomy</b>	<p><b>Roots (Typically 3 of them):</b></p> <ul style="list-style-type: none"> <li>- <b>Palatal:</b> Long, round, large diameter, Angled away from the crown, Apical curve to the buccal             <ul style="list-style-type: none"> <li>- Apical Curve to buccal <b>makes your filling and WL look short</b> -&gt; Need Apex locator!</li> </ul> </li> <li>- <b>Distobuccal:</b> Round, Conical, Straight, Distal dilaceration</li> <li>- <b>Mesiobuccal:</b> Wide Ovoid, 2 canal system             <ul style="list-style-type: none"> <li>- MB2 is straight palatal from MB1</li> <li>- MB2 is much smaller than MB1 and easy to miss</li> <li>- MB2 usually has a mesial curve while MB1 is straight</li> </ul> </li> </ul> <p><b>Canals:</b></p> <table border="1" data-bbox="331 418 894 601"> <tbody> <tr> <td><b>Max 1<sup>st</sup></b></td><td>4 Canals -&gt; 90% 3 Canals -&gt; &lt;10% 5+ Canals -&gt; &lt;1%</td> </tr> <tr> <td><b>Max 2<sup>nd</sup></b></td><td>4 Canals: &gt;50%</td> </tr> <tr> <td><b>Max 3<sup>rd</sup></b></td><td>Even spread of 1, 2, 3, 4, canals in 1, 2, or 3 roots</td> </tr> </tbody> </table>	<b>Max 1<sup>st</sup></b>	4 Canals -> 90% 3 Canals -> <10% 5+ Canals -> <1%	<b>Max 2<sup>nd</sup></b>	4 Canals: >50%	<b>Max 3<sup>rd</sup></b>	Even spread of 1, 2, 3, 4, canals in 1, 2, or 3 roots
<b>Max 1<sup>st</sup></b>	4 Canals -> 90% 3 Canals -> <10% 5+ Canals -> <1%						
<b>Max 2<sup>nd</sup></b>	4 Canals: >50%						
<b>Max 3<sup>rd</sup></b>	Even spread of 1, 2, 3, 4, canals in 1, 2, or 3 roots						
<b>Access</b>	<p>Triangular or Trapezoidal outline access</p> <ul style="list-style-type: none"> <li>- Base of the triangle at the buccal, converging palatally</li> </ul>  <p><b>DON'T LEAVE MB<sub>2</sub>..its there 90% of the time</b></p> <ul style="list-style-type: none"> <li>- From MB1 go <b>straight palatally and parallel to the root curvature</b></li> </ul> <p><b>Other Access Variations:</b></p>  						
	<p><b>**Can usually leave the transverse ridge alone!**</b></p>						
<b>Instrumentation</b>	<p>Confirm if MB1 and MB2 join or exit in separate foramina</p>						
	<ul style="list-style-type: none"> <li>- Place 2 files in: if both go to full WL then they exit separately, if 1 is short the might connect (confirm this by pulling out the full length file and seeing if that allows the short one to go further)</li> </ul>						
<b>Obturation</b>	<p>Begin with the largest canal first</p> <ul style="list-style-type: none"> <li>- <b>Palatal</b></li> </ul> <p><b>Then the DB Canal</b></p> <p><b>Finally the MB Canal</b></p> <ul style="list-style-type: none"> <li>- If there is no room, do the P and DB trial cone fil first and obturate MB separately with a separate trial cone film</li> </ul> <p><b>** If you need to redo the GP</b></p> <ul style="list-style-type: none"> <li>- Use H-file #30, #35, or #40, in 2 to 3 twists into GP and pull out by hand</li> </ul>						

# Apexification / Apexogenesis

## Apexification

<b>Definition</b>	Method for inducing apical closure by formation of osteocementum (or similar hard tissue) of an incompletely formed root with a <b>non-vital</b> pulp
<b>Objective</b>	Be able to obturate the root canal and have the filling material stay within in the canal system and not blast out the end <ul style="list-style-type: none"> <li>- How? Stimulate hard tissue barrier/calcified tissue formation at the apex</li> </ul>  <p>-&gt; Avoid this out the end of your immature tooth</p>
<b>Technique</b>	
<b>Diagnosis</b>	Pulpal Necrosis is a must -> Tooth must be non-vital <ul style="list-style-type: none"> <li>- Cold and EPT tests aren't very reliable for immature teeth. A sinus tract tracing to the tooth is a good indication of necrosis though</li> </ul>
<b>Access</b>	Straight line access as usual (easy to achieve to the apical 3 <sup>rd</sup> of immature teeth) <ul style="list-style-type: none"> <li>- Remove all remaining radicular pulp like a normal endo</li> </ul>
<b>Instrumentation</b>	Determine the WL -> Obviously a #15 file will be too small. <b>Probably an 80-140</b> can just engage the walls, hold it in place with a cotton pellet stuffed in the access cavity <ul style="list-style-type: none"> <li>- We don't do the normal 3 sizes beyond the first binding instrument. Just place the first one to engage the walls</li> <li>- <b>Apex locators are not usually accurate because the apical foramen is wide open</b></li> </ul>
<b>Drying Canal</b>	Use paper points upside down -> large end in the canal first
<b>Placing Medicament</b>	<p><b>Traditional Approach</b></p> <ul style="list-style-type: none"> <li>- <b>Ca(OH)<sub>2</sub></b> paste is placed for a long time to stimulate apical closure</li> <li>1. GENTLY spin Ca(OH)<sub>2</sub> into canal with lentulo spiral</li> <li>2. <b>Ca(OH)<sub>2</sub></b> will wash out over time -&gt; Change it every 6wks – 3 mon. (or if it lasts longer you can do 3-6mo)</li> <li>3. Take new radiograph every 6 months to evaluate hard tissue formation <ul style="list-style-type: none"> <li>- Also check <b>clinically how it is forming with a min. #40 file</b></li> <li>- Caution: B-L plane of canal is the last to converge, the radiograph may show a convergent apex M-D, but B-L is still divergent. Hence why we need to double check with file</li> </ul> </li> </ul> <p><b>Contemporary Approach</b></p> <ul style="list-style-type: none"> <li>- <b>Ca(OH)<sub>2</sub></b> only placed for short 2wk period to disinfect, then it is replaced with a barrier material we can obturate against (MTA, Biobentin etc)</li> <li>1. Ca(OH)<sub>2</sub> paste placed into canals to disinfect for 2 weeks</li> <li>2. Remove Ca(OH)<sub>2</sub> and place <b>MTA in the apical part of the canal</b> -&gt; Creates an apical plug that will promote repair</li> <li>3. Once MTA is hard -&gt; Root canal is <b>obturated with gutta percha to below CEJ</b></li> <li>4. Place resin bonded material (RMGIC, Composite) in access cavity to below the CEJ to ↑ root fracture resistance</li> </ul> 
<b>Seal</b>	Traditional + Contemporary approach <ul style="list-style-type: none"> <li>- Fill chamber with cotton pellet</li> <li>- Cover with hard setting temp material (Cavit alone is too soft and will wash out) <ul style="list-style-type: none"> <li>- Can do Cavit + Covered with GI or Composite</li> </ul> </li> </ul>
<b>Recall + Maintenance</b>	Traditional <ul style="list-style-type: none"> <li>- <b>6wk, 3mon, 6mon</b> -&gt; Depends on how fast it is washing out</li> <li>- Maintain Ca(OH)<sub>2</sub> in the canal until a hard tissue barrier is formed -&gt; might take 2-3 years</li> </ul>
<b>Final Obturation</b>	Traditional <ul style="list-style-type: none"> <li>- May need to roll 2 large diameter GP cones together to create a monster phatty to fill the canal</li> <li>- Thermoplasticized GP works like a charm</li> </ul>

## Apexogenesis

<b>Definition</b>	<b>Vital</b> pulp therapy of an immature adult tooth to directly maintain pulp vitality and allow the tooth root to mature and develop
<b>Technique</b>	
<b>Diagnosis</b>	<b>Vital</b> pulp tissue remains at some level in the root canal system
<b>Access</b>	<p><b>Remove necrotic pulp tissue to the level of the vital tissue</b></p> <ul style="list-style-type: none"> <li>- Place a paper point into the canal slowly until Pt feels it. Mark that depth and remove tissue until that level</li> </ul> <p><b>DON'T place hand file in the canal to determine WL</b> -&gt; Patient can feel it at some point and they will hate you, it also damages the vital pulp</p>
<b>Instrumentation</b>	<p><b>Amputate the coronal pulp</b> tissue to the level that you have noted vitality</p> <ul style="list-style-type: none"> <li>- In multirooted teeth only remove the pulp from the chamber (leave the canal tissue)</li> <li>- In single rooted teeth, remove affected pulp from chamber to the level of healthy pulp (Typically removing 1-2mm of inflamed pulp tissue)</li> </ul> <p><b>Control hemorrhage</b></p> <ul style="list-style-type: none"> <li>- Apply pressure with NaOCl moistened cotton pellet for 5 minutes</li> <li>- Place Ca(OH)<sub>2</sub> powder onto the bleeding tissue</li> </ul>
<b>Placement of Medicament</b>	<ol style="list-style-type: none"> <li>1. <b>Wash out Ca(OH)<sub>2</sub></b> powder from the canal space</li> <li>2. Place a <b>hard setting material (Dycal, MTA, Biodentin etc)</b> placed over the pulp stumps -&gt; <b>Pulp Capping</b>. IRM can be used as a base and temp filling material</li> </ol>
<b>Seal</b>	After <b>base (GIC)</b> is laid down over pulp capping materials fill with <b>bonded resin (RMGIC, Composite etc)</b>
<b>Recall</b>	<p><b>6mo, 1yr, 2yr</b></p> <ul style="list-style-type: none"> <li>- Check for signs of vitality and pulpal pathoses</li> <li>- Monitor apex closure as well</li> </ul> <p>Might need to do endo as well if pulp was unable to be saved and went necrotic</p>

## Regeneration

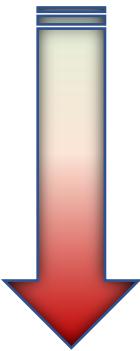
<b>Definition</b>	= Stimulate the growth of tissue back into the root canal of a previously necrotic tooth -> regenerating the normal tissue and function of the pulp = Formation of a hard tissue within the root canal that previously did not exist
<b>Diagnosis</b>	Immature teeth with Apical Periodontitis + Negative pulp response
<b>Steps</b>	<p><b>Appointment 1</b></p> <ol style="list-style-type: none"> <li>1. Assess the where/if there is any vital tissue in the pulp chamber or canals -&gt; Remove necrotic tissue coronally to the vital tissue</li> <li>2. Irrigate well (and in the apical 3<sup>rd</sup>) with NaOCl</li> <li>3. Dry with paper points</li> <li>4. Apply either Ca(OH)<sub>2</sub> or Triple antibiotic Paste (1mg/mL) -&gt; caution with Minocycline in the paste, it can stain the teeth and cause esthetic issues</li> <li>5. Seal with cotton pellet and temporary filling</li> </ol> <p><b>Appointment 2 (3-4 weeks later)</b></p> <ul style="list-style-type: none"> <li>- Pt should have ↓ signs and symptoms</li> </ul> <ol style="list-style-type: none"> <li>1. Give LA without vasoconstrictor (inducing bleeding this appointment and the vasoconstrictor will prevent that)</li> <li>2. Irrigate with EDTA and clean out the remnants of appointment 1 thoroughly (use a small file if needed) <ul style="list-style-type: none"> <li>- DON'T use NaOCl this appointment because it kills the stem cells you are going to elicit</li> <li>- EDTA stimulates stem cells and growth factor release</li> </ul> </li> <li>3. Stimulate bleeding of the tissue by inserting paper point a few mm beyond the apical foramen + lacerate apical tissue to bleed 3mm below the CEJ</li> <li>4. Place a collagen matrix (Collaplug) to help MTA placement</li> <li>5. Place 3mm of MTA or Biodentin (for esthetic areas)</li> <li>6. Restore with composite</li> </ol>

### Uses for Ca(OH)<sub>2</sub>

1. Vital Pulp Therapy
  - Direct/Indirect Pulp Capping
  - Pulpotomy (Permanent teeth)
  - Apexogenesis (Immature teeth)
2. Open Apex Closure (Non-vital therapy)
  - Apexification
3. Intracanal Dressing

# Etiology and Pathogenesis

Pulp issues are progressive



- Healthy Pulp 😊
- Pulpitis
  - Reversible
  - Irreversible
- Pulpal Necrosis
  - **Sterile necrosis -> Trauma induced.** Apical foramen is only 0.1mm square, easy to sever the neurovascular connection.  
Will be symptom free for 5-15 years before an infection begins
  - **Infected Necrosis -> Infection induced**
- Periapical involvement (ALWAYS caused by infected necrosis, never by sterile necrosis)
  - Apical Periodontitis
  - Radicular Cyst -> A unique cyst in that it does not exist without Apical periodontitis. So it's AP + Cyst

Apical Periodontitis is **CAUSED** by bacteria -> Usually asymptomatic at time of Dx

- Necrotic pulp tissue alone cannot cause apical periodontitis, need bacteria

<b>Irritation of the pulp</b>	<table border="0" style="width: 100%;"> <tr> <td style="vertical-align: top; width: 30%;"> <b>Physical Chemical</b> <ul style="list-style-type: none"> <li>- These usually are not toxic enough to cause necrosis, it's usually leakage causing the problem</li> </ul> </td><td style="vertical-align: top; width: 70%;"> <b>Microbial</b> <ul style="list-style-type: none"> <li>- <b>Pulp reacts to early infiltration of microbes.</b> They send antigens down the dentin tubules and pulp recedes away from the source before it reaches the pulp fully. Inflammatory rxn early on causes the recession</li> <li>- 1-2mm away from the bacterial invasion the pulp is usually resilient and healthy</li> </ul> </td></tr> </table> <div style="text-align: center; margin-top: 10px;"> <p>Courtesy Dr D Ricucci</p> </div>	<b>Physical Chemical</b> <ul style="list-style-type: none"> <li>- These usually are not toxic enough to cause necrosis, it's usually leakage causing the problem</li> </ul>	<b>Microbial</b> <ul style="list-style-type: none"> <li>- <b>Pulp reacts to early infiltration of microbes.</b> They send antigens down the dentin tubules and pulp recedes away from the source before it reaches the pulp fully. Inflammatory rxn early on causes the recession</li> <li>- 1-2mm away from the bacterial invasion the pulp is usually resilient and healthy</li> </ul>
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<b>Microbiology of Apical Periodontitis</b>	<p><b>At Primary Tx:</b></p> <ul style="list-style-type: none"> <li>- <b>Anaerobes dominate, w/ frequent facultatives</b></li> <li>- Composition is similar to perio pocket flora</li> <li>- Polymicrobial (2-10 species per canal)</li> <li>- No Enteric or Yeast species present</li> </ul> <p><b>**Anaerobic bacteria can cause inflammation, but are easily managed with endo Tx**</b></p> <p><b>Previously Treated (and re-infected)</b></p> <ul style="list-style-type: none"> <li>- ↑ Facultatives (E.faecalis in particular)</li> <li>- ↑ Gram + and – Rods</li> <li>- ↓ Anaerobic bacteria</li> <li>- ↑ Enterics and Yeasts</li> </ul> <p><b>**These are more resistant to the typical root canal medicaments, **</b></p>		
<b>Pathogenesis of the PA Lesion</b>	<ol style="list-style-type: none"> <li>1. Bacteria reach the apical portion of the root</li> <li>2. Defense cells at the apical foramen hold the bacteria back and keep them in the root canal</li> <li>3. Defense cells activate Osteoclasts though -&gt; These cells then chew up the bone around the root. Bacteria don't directly cause the bone removal</li> <li>4. <b>If bacteria actual reach the bone = Osteomyelitis</b></li> </ol> <div style="text-align: center; margin-top: 10px;"> <p>Osteoclast activation</p> </div>		

## Pulpitis

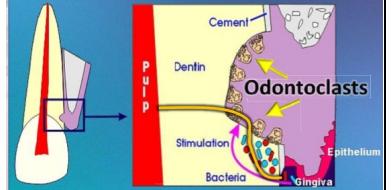
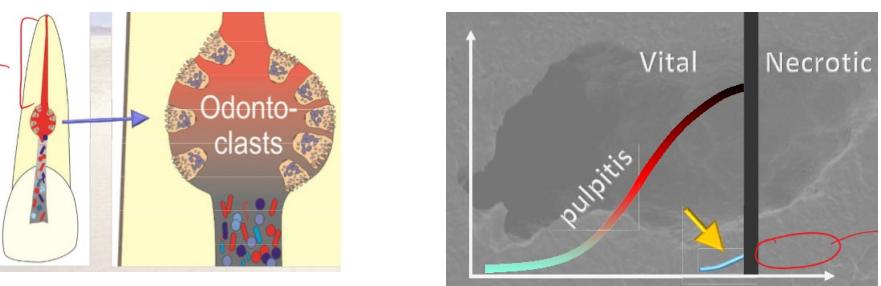
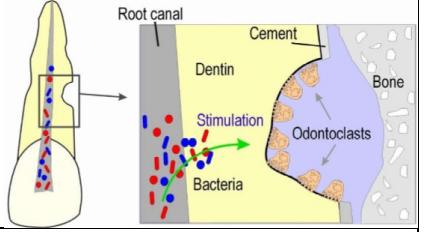
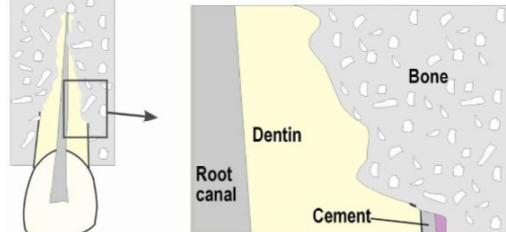
Exposed dentin doesn't guarantee pulpal exposure to bacteria -> Attrition, erosion etc

- Even if the chamber is infected, we should assume the canals are sterile and no biofilm has yet been established there

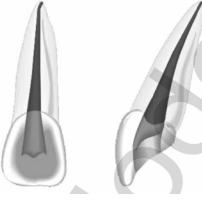
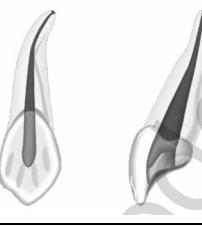
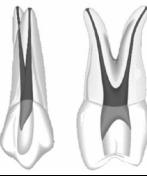
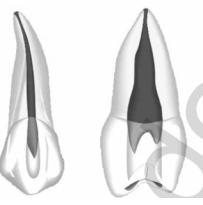
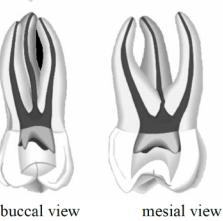
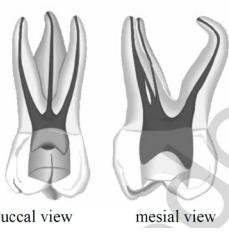
Can have pulpitis even with an intact crown...how!?

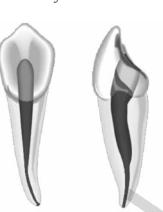
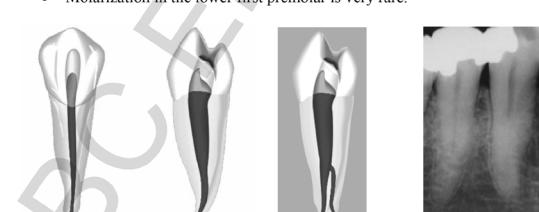
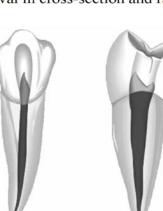
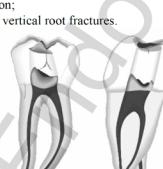
- Deep Perio pockets can give bacteria access to lateral canals
- Microcracks
- Dens Evaginatus

## Resorptions

<b>Cervical Resorption</b>	<p><b>NOT caused by bacteria</b></p> <ul style="list-style-type: none"> <li>- Inflammation in the sulcus stimulates osteoclasts</li> </ul> 
<b>Internal Inflammatory Root Resorption</b>	<p><b>IS caused by bacteria -&gt; Infected VITAL root</b></p> <ul style="list-style-type: none"> <li>- Resorption begins as pulpitis is progressing, but as soon as the tooth becomes necrotic the resorption stops</li> </ul> 
<b>Surface Resorption</b>	<p>Frequently found after ortho treatment</p> <ul style="list-style-type: none"> <li>- Pre-cementum on the outside of the root prevents osteoclasts from binding and resorbing. In cases of trauma or inflammation when that layer is disturbed osteoclasts are able to bind and erode the external surface of the root</li> </ul>
<b>External Inflammatory root resorption</b>	<p>Caused by <b>intrusion trauma -&gt; Starts at Surface resorption as a result of trauma...when the resorption opens up patent dentinal tubules. Bacteria in an infected pulp propagate the resorption.</b></p> <ul style="list-style-type: none"> <li>- Bacterial within the canal stimulate the activation of Osteoclasts on the outside of the root surface</li> </ul> 
<b>Replacement Resorption (Ankylosis)</b>	<p>Eventually the root material is replaced with bone</p> <ul style="list-style-type: none"> <li>- Usually a complication of an avulsed tooth replaced into the socket. Without the PDL and the inhibiting layer on the root preventing Osteoclast adhesion the tooth is resorbed and replaced with bone -&gt; PDL is key here, without it we get replacement resorption</li> </ul> 

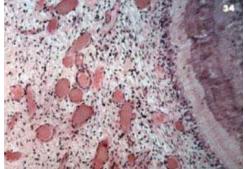
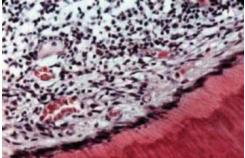
# Anatomy

<p><b>Maxillary Central Incisor</b></p> <ul style="list-style-type: none"> <li>Usually straight root, single canal;</li> <li>The cross-section of the canal is fairly round;</li> <li>Two canals in one or two roots have been published and this could be related to fusion or incomplete gemination;</li> <li>Assume that 99% of these teeth have one canal but review radiograph and be prepared for variations such as invagination.</li> </ul> 	<p><b>Maxillary Lateral Incisor</b></p> <ul style="list-style-type: none"> <li>Usually one canal and one root but like the central incisor, cases have been reported where two canals are present in one or two roots;</li> <li>The cross section is oval or round;</li> <li>The root tip often dilacerates distally and/or palatally or labially (which is difficult to see in the radiograph);</li> <li>Dens Invaginatus (Dens Endente, Tooth in a Tooth) is a common anatomical variation;</li> <li>Lingual Radicular Groove is often associated with the external root surface of this tooth and provides a pathway for salivary leakage to the root apex.</li> </ul> 
<p><b>Maxillary Canine</b></p> <ul style="list-style-type: none"> <li>Has the longest and strongest root;</li> <li>Often dilacerates to the distal / labially;</li> <li>Has only one canal and one root;</li> <li>The cross section is usually oval;</li> <li>The root canal is typically quite large, but often the few most apical millimeters before the foramen are much narrower</li> </ul> 	<p><b>Maxillary First Bicuspid</b></p> <ul style="list-style-type: none"> <li>Usually has two roots and two root canals, occasionally only one root is present, but even then two canals are still often found;</li> <li>The root tips and apical canals may curve in the mesio-distal or bucco-palatal dimensions;</li> <li>The roots are often equally long but 1 - 2 mm differences may occur;</li> <li>the mesial and distal aspects of the root are often concave;</li> <li>The root tips can be extremely fine, which may result in perforation even in a straight canal if a large apical open size is attempted</li> <li>usually two canals, but also one canal (10-20%) or three canals (molarization, 1%) can be present;</li> </ul> 
<p><b>Maxillary Second Bicuspid</b></p> <ul style="list-style-type: none"> <li>Often seen with a single bayonet shaped root;</li> <li>The root is normally straight but may curve in the apical area, particularly distally;</li> <li>Often has two canals in a single root but in many cases they unite before the apical foramen.;</li> <li>Can have three canals (molarization, 1%).</li> </ul> 	<p><b>Maxillary First Molar</b></p> <ul style="list-style-type: none"> <li>Maxillary molars have from one to three roots and from two to four root canals. From an occlusal view, the pulp chamber is situated rather mesially, which has to be taken into account when cutting the access cavity.</li> <li><b>PALATAL ROOT</b> <ul style="list-style-type: none"> <li>Largest of the three;</li> <li>Round or flat/oval, straight until apical canal which often curves buccally;</li> <li>Sometimes two palatal canals are found in the root and may converge to form one large ovoid or elliptically shaped canal with a common apex.</li> <li>Often 1-2 mm longer than the buccal canals.</li> <li>Two palatal roots in the upper first molar have been reported in the literature.</li> </ul> </li> <li><b>DISTO-BUCCAL ROOT</b> <ul style="list-style-type: none"> <li>Usually round and straight, may curve mesially, or sometimes distally;</li> <li>Often has a distal dilacerations.</li> </ul> </li> <li><b>MESIO-BUCCAL ROOT</b> <ul style="list-style-type: none"> <li>The mesiobuccal root is the most challenging to treat;</li> <li>Often dilacerated distally;</li> <li>Usually has two canals, MB1 and MB2, the latter is usually difficult to find by clinical inspection and is not apparent in the radiograph, it is typically situated near the mesial wall of the pulp chamber orifice is usually located 1 - 3 mm palatally from the mesiobuccal canal;</li> <li>The root is usually curved all the way to the apex, which increases the risk of tip perforation and strip perforation if instrumented with traditional techniques using stiff steel instruments;</li> <li>The distal surface of the root is concave which increases the risk of strip perforation;</li> <li>In most cases, the MB2 canal joins the mesiobuccal canal before the apex.</li> </ul> </li> </ul>
<p><b>Maxillary Second Molar</b></p> <ul style="list-style-type: none"> <li>Resembles the first molar;</li> <li>Has three, four, two, or one canals;</li> <li>two palatal roots rare ;</li> <li>The orifices of the mesiobuccal and distobuccal canals are closer together sometimes the two buccal canals are side by side in the mesio-distal dimension, and sometimes form a line with the palatal canal orifice.</li> <li>Can have one large buccal root and canal approximately the same size as the palatal root and canal</li> </ul> 	 <p>buccal view      mesial view</p>

<p><b>Mandibular Central Incisor</b></p> <ul style="list-style-type: none"> <li>• 80% has one root canal, 20% two canals that often join before the apical foramen;</li> <li>• Usually has a straight root;</li> <li>• The canal(s) is very flattened: wide in the bucco-lingual dimension and narrow in the mesio-distal dimension. Only the most apical part of the canal is more round;</li> <li>• The long axis of the canal traverses the incisal edge or the labial surface of the crown, and the access opening is made on the lingual surface, for aesthetic reasons, there is always a risk that the lingual canal is missed unless it is detected from the pre-treatment radiograph and specifically looked for with a pre-curved file.</li> </ul> 	<p><b>Mandibular Lateral Incisor</b></p> <ul style="list-style-type: none"> <li>• Similar to the central incisor;</li> <li>• Usually has a 1-2 mm longer root than the central incisor;</li> <li>• Often has a slight distal dilaceration.</li> </ul> 
<p><b>Mandibular Cuspid</b></p> <ul style="list-style-type: none"> <li>• The mandibular canine is the second longest tooth in the dentition, it is only 1 - 2 mm shorter than the upper canine</li> <li>• Longer and wider root than the other mandibular incisors;</li> <li>• Ovoid root canal is common;</li> <li>• Two canals in one root (or two roots; one buccal and one lingual) present in 20%, often join before apex;</li> <li>• Usually a straight root and canal, but sometimes the root tip and the canal curve distally and/or labially.</li> </ul> 	<p><b>Mandibular First Bicuspid</b></p> <ul style="list-style-type: none"> <li>• Usually 1 root canal (70%), often two canals (30%), sometimes more than two canals in one root;</li> <li>• If one canal is present, oval in cross-section and seldom curves severely and is quite easy to instrument;</li> <li>• When there are two canals, the files usually easily find the buccal canal, while the lingual canal often requires bending of the instrument tip. Second canal is readily detectable from the pre-treatment radiograph as a suddenly disappearing canal shadow;</li> <li>• Molarization in the lower first premolar is very rare.</li> </ul> 
<p><b>Mandibular Second Bicuspid</b></p> <ul style="list-style-type: none"> <li>• Usually one canal in the second bicuspid, the lingual canal is present only occasionally;</li> <li>• Molarization is more frequent than in the first premolar, yet still quite rare;</li> <li>• The root canal is oval in cross-section and rather straight with only a slight distal curvature.</li> </ul> 	<p><b>Mandibular First Molar</b></p> <ul style="list-style-type: none"> <li>• It usually has 3 - 4 canals, two in the mesial root and one or two in the distal root.</li> <li>• Mandibular first molars with two canals are rare.</li> <li>• <b>DISTAL ROOT</b> <ul style="list-style-type: none"> <li>- has often two canals with either a common apical foramen or two separate foramina;</li> <li>- Canal can be ovoid or hour-glass shaped;</li> <li>- Usually never round;</li> <li>- Wider Bucco-lingually than Mesio-distally;</li> <li>- Often the most apical 1 - 2 mm of this canal curves up to 90 degrees distally, may also curve mesially, but not sharply.</li> </ul> </li> <li>• <b>MESIAL ROOT</b> <ul style="list-style-type: none"> <li>- Usually two canals; sometimes three, rarely only one mesial canal</li> <li>- Often dilacerates distally at apex;</li> <li>- Isthmus between canals may be present;</li> <li>- Middle mesial canal occasionally found;</li> <li>- Both the mesiobuccal and mesiolingual canals are usually curved along their whole length, and the curvature is typically greatest in the apical region;</li> <li>- The canals curve distally, but they also curve buccally or lingually at the same time.</li> </ul> </li> </ul> 
<p><b>Mandibular Second Molar</b></p> <ul style="list-style-type: none"> <li>• Much like the Mandibular First Molar with milder curvature;</li> <li>• Can have one root, with one, two or even three canals;</li> <li>• The mesiobuccal or mesiolingual canal joins the distal canal, sometimes both mesial canals join the distal canal;</li> <li>• "C" shaped canal found in 1% in caucasian population, more frequent in asian population;</li> <li>• Susceptible to vertical root fractures.</li> </ul> 	<p><b>Maxillary and Mandibular Third Molars</b></p> <ul style="list-style-type: none"> <li>• These teeth can have a variety of various root canal arrangements and short, dilacerated roots;</li> <li>• Sometimes difficult to treat, in such cases treatment is rendered only if it is imperative to retain the tooth</li> </ul>

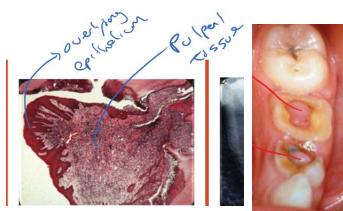
# Pathology of Pulpal and Periapical Lesions

## Pulpal Lesions

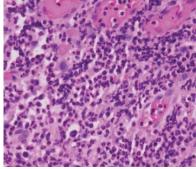
Pulpitis	
<b>Definition</b>	<p>Inflammation of pulpal tissues</p> <ul style="list-style-type: none"> <li>- Not necessarily an infection! Could be caused by trauma etc</li> </ul> <p>Because we don't have direct access to assess the pulp we need to use indirect assessments:</p> <ul style="list-style-type: none"> <li>- Hx</li> <li>- Clinical examination (Pulpal testing)</li> </ul>
<b>Causes</b>	<ol style="list-style-type: none"> <li>1. <b>Bacteria</b> and Bacterial Products <ul style="list-style-type: none"> <li>- Caries, Coronal cracks, Periodontal pockets, Malformed teeth, Dens invaginatus)</li> </ul> </li> <li>2. <b>Trauma</b> <ul style="list-style-type: none"> <li>- Coronal/Root Fractures, Partial avulsion, Bruxism, Abrasion</li> <li>- Less so with Bruxism though as tertiary dentin gets laid down to protect the pulp</li> </ul> </li> <li>3. <b>Iatrogenic</b> <ul style="list-style-type: none"> <li>- Heat generation, Deep Preps/resto's, Dehydration of tubules, Pulp exposure, Filling materials</li> </ul> </li> </ol>
<b>Pulp Chamber Anatomy</b>	<p>End-Artery No Significant collateral blood supply Confined inside dentinal hard tissue Few access openings (Apical foramen, Accessory canal)</p> <p>Chamber volume and opening apertures get smaller with time as secondary/Tertiary dentin is laid down</p> <ul style="list-style-type: none"> <li>- Pros: ↑ protection from insults</li> <li>- Cons: ↓ accommodation for tissue expansion during inflammation</li> </ul>
<b>Pulpal Inflammation</b>	Confined Space + Expansile process = Pain, ↑ internal pressure, occlusion of blood supply leading to possible necrosis
<b>Histopathology of pulpal disease</b>	<p>* There is no correlation between clinical and histopathologic disease states*</p> <ul style="list-style-type: none"> <li>- Clinical and Histopathologic disease are a part of a spectrum (there are no discrete states)</li> </ul> <p><b>Pulpal Hyperemia</b></p> <ul style="list-style-type: none"> <li>- ↑ Blood Flow</li> <li>- May be present in <i>Reversible Pulpitis</i></li> <li>- <b>Dilation of capillaries</b> and interstitial edema</li> <li>- Mild acute inflammatory exudate and chronic lymphocytic infiltrate</li> </ul> <p><b>Acute to Chronic Pulpitis</b></p> <ul style="list-style-type: none"> <li>- Mixed inflammatory rxn may be present in <i>irreversible pulpitis</i></li> <li>- Dilated capillaries and neutrophils suggest acute inflammation</li> <li>- Lymphocytes and Fibroblasts suggest chronic inflammation</li> </ul>  

## Diagnosis

<b>Techniques</b>	<p><b>CC and Hx</b></p> <ul style="list-style-type: none"> <li>- Nature of pain, duration, aggravating/alleviating factors</li> </ul> <p><b>Clinical Inspection</b></p> <ul style="list-style-type: none"> <li>- Tooth discolouration, Fistulas, Caries</li> </ul> <p><b>Radiographs</b></p> <ul style="list-style-type: none"> <li>- Radiolucency, PDL widening, Lamina dura, Caries, Fractures</li> </ul> <p><b>Palpation (Periapical assessment)</b></p> <ul style="list-style-type: none"> <li>- Lymphadenopathy, Swellings, Perio probing</li> </ul> <p><b>Percussion (Periapical assessment)</b></p> <ul style="list-style-type: none"> <li>- Assess presence/Quality of pain</li> </ul> <p><b>Endodontic Testing (Pulpal assessment)</b></p> <ul style="list-style-type: none"> <li>- Heat/Cold/Electric</li> </ul>
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<b>Reversible Pulpitis</b>	<p>Pulp is capable of fully recovering if the etiology of the inflammation is removed</p> <p><u>Assessment:</u></p> <ul style="list-style-type: none"> <li>- Acutely painful when stimulus is applied (usually cold) -&gt; <b>Resolves in seconds</b></li> <li>- <b>Non-spontaneous pain</b></li> </ul> <p><u>Patho -&gt; Mild/Early Inflammation</u></p> <ul style="list-style-type: none"> <li>- Vasodilation, Transudation w/ ↑ permeability of venules</li> <li>- Mild PMN and Lymphocyte infiltration</li> <li>- ↑ pressure on odontoblasts and A<sub>δ</sub> fibers (↑ sensitivity)</li> </ul> <p><u>Tx:</u></p> <ul style="list-style-type: none"> <li>- <b>Remove the irritant</b> (caries, exposed dentin etc) and repair damage</li> </ul>
<b>Irreversible Pulpitis</b>	<p>Pulp will not recover with Tx -&gt; RCT is needed</p> <p><u>Assessment:</u></p> <ul style="list-style-type: none"> <li>- Spontaneous prolonged pain (Dull), could be referred to another tooth/structure and hard to localize</li> </ul> <p><u>Patho -&gt; Longstanding chronic inflammatory condition</u></p> <ul style="list-style-type: none"> <li>- ↑ vascularity and congestion may cause local vascular strangulation (↓ O<sub>2</sub> to pulpal tissue)</li> <li>- ↓ removal of cellular metabolic waste -&gt; <b>Cellular breakdown and death = ↑ inflammatory response further</b></li> <li>- ↑ pulpal pressure causes <b>spontaneous and persistent pain</b></li> </ul> <p><u>Tx: Endo or Exo</u></p>
<b>Pulpal Necrosis</b>	<p>She Died -&gt; Result of chronic pulpitis or trauma-induced immediate ischemia</p> <ul style="list-style-type: none"> <li>- Can cause nerve degeneration, <b>making the tooth asymptomatic</b></li> </ul> <p><u>Assessment:</u></p> <ul style="list-style-type: none"> <li>- <b>No symptoms or pain in the pulp</b> <ul style="list-style-type: none"> <li>- No EPT response (reading of 80)</li> <li>- No thermal response</li> </ul> </li> <li>- Necrotic biproducts may induce inflammation and pain in the periapical tissue <ul style="list-style-type: none"> <li>- Percussion sensitivity</li> </ul> </li> <li>- <b>Tooth may be discolored</b> -&gt; Tissue debris and erythrocyte hemosiderin accumulating in the dentinal tubules</li> </ul>
<b>Chronic Hyperplastic Pulpitis</b>	<p>Rare condition -&gt; Found mostly in recently erupted molars w/ extensive caries</p> <ul style="list-style-type: none"> <li>- <b>Caries causes disintegration of the enamel and dentin before the young immature pulp becomes infected</b></li> </ul> <p><u>Patho:</u></p> <ul style="list-style-type: none"> <li>- Pulp is supported by good blood supply and its young <b>regenerative capacity</b></li> <li>- Pulp forms <b>granulation tissue and surface overlying stratified squamous epithelium</b> -&gt; If hyperplastic can form a <b>pulp polyp</b> (Basically epithelium grows overtop of pulp and it can grow through the cavitation of the enamel and dentin)</li> </ul> <div style="text-align: right;">  </div>

## Periapical Lesions

Lesion	Things about it
<b>Chronic Apical Periodontitis (Periapical Granuloma)</b> 	<p><u>Radiographically:</u></p> <ul style="list-style-type: none"> <li>- Widened PDL/Periapical radiolucency</li> <li>- Discontinuous Lamina Dura</li> <li>- If longstanding -&gt; Possible apical hypercementosis w/ ↑ density of surrounding bone</li> </ul> <p><u>Clinically:</u></p> <ul style="list-style-type: none"> <li>- Minimal pain or Asymptomatic</li> <li>- Possible sensitive to percussion</li> </ul> <p><u>Histologically:</u></p> <ul style="list-style-type: none"> <li>- Chronic inflammatory cell infiltrate (Lymphocytes, Plasma cells, Macrophages)</li> <li>- Background of dense collagen Fibrovascular CT</li> <li>- Fibroblasts</li> </ul>
<b>Acute Exacerbation of Chronic Apical Periodontitis</b> 	<p>May be associated w/ a <b>symptomatic flare of chronic apical periodontitis</b></p> <ul style="list-style-type: none"> <li>- Just because its painful, doesn't mean its an acute exacerbation</li> </ul> <p><u>Histologically:</u></p> <ul style="list-style-type: none"> <li>- Collections of PMN's are seen</li> </ul> 
<b>Suppurative Apical Periodontitis / Draining Cyst</b>	<p>Acute inflammatory flare-up of chronic apical periodontitis -&gt; <b>Opens into a parulis (Gum boil) with drainage of pus through a fistula into the oral cavity.</b></p> <ul style="list-style-type: none"> <li>- Typically not painful b/c there is no buildup of pressure</li> </ul> <p><u>Histologically:</u></p> <ul style="list-style-type: none"> <li>- No epithelium, lined with granulation tissue instead</li> </ul>
<b>Periapical Cyst</b> 	<p>Common development of <b>longstanding, untreated chronic apical periodontitis</b></p> <p>Rests of Malassez enlarge in response to inflammation from bacterial infection of pulp or pulpal necrosis -&gt; These rests are concentrated at the apical region</p> <ul style="list-style-type: none"> <li>- If inflammation persists epithelium is stimulated and proliferates to form a cyst</li> </ul> <p>Cells get nutrients and remove metabolic biproducts via diffusion -&gt; Only works a few cell layers away though, so as the cyst grows the cells in the middle are starved of O<sub>2</sub> and biproducts ↑ causing more growth</p> <p><u>Histologically:</u></p> <ul style="list-style-type: none"> <li>- Non-keratinized, squamous epithelium of variable thickness +/- inflammation</li> <li>- CT wall -&gt; inflammatory infiltrate +/- cholesterol crystals, foreign body giant cells, hemosiderin</li> </ul> <p><u>Tx:</u></p> <ul style="list-style-type: none"> <li>- Enucleation after extraction or endo</li> <li>- If you only drain the cyst w/o enucleation it will likely come back</li> <li>- If you only extract or Endo (w/o enucleation) you will leave a Residual Cyst</li> </ul> <p>Connective Tissue lined by Epithelium, filled with fluid</p>
<b>Periapical Scar</b>	<p>Apical RL of pulpal origin that <b>doesn't respond to Tx</b>, and persists radiographically</p> <p><u>Radiographically:</u></p> <ul style="list-style-type: none"> <li>- Can't differentiate btwn Apical scar and Apical periodontitis -&gt; <b>if asymptomatic for a long time it's likely an apical scar</b></li> </ul> <p><u>Histologically:</u></p> <ul style="list-style-type: none"> <li>- Dense collagenous CT devoid of inflammatory infiltrate</li> </ul>
<b>Periapical Abscess</b>	<p>Can arise de-novo or as an acute exacerbation of a chronic state (Phoenix Abscess)</p> <ul style="list-style-type: none"> <li>- <b>Contaminants (cell debris, enzymes, toxins) exit through the apex and stimulate periodontal tissue and adjacent alveolar bone</b> (Spread of infection and inflammation from the pulp)</li> </ul> <p>Etiology similar to acute pulpitis (Caries, trauma, iatrogenic)</p> <p><u>Clinically:</u></p> <ul style="list-style-type: none"> <li>- <b>Severe Pain</b></li> <li>- <b>Febrile Pt w/ malaise</b></li> <li>- Tooth <b>extruded from socket</b> (from inflammation in PDL) -&gt; Sharp pain on biting</li> <li>- Tooth <b>sensitive to percussion but may be insensitive or unresponsive to thermal stim.</b> (b/c pulpal tissue is dead, symptoms are from apical tissue)</li> </ul> <p><u>Radiographically:</u></p> <ul style="list-style-type: none"> <li>- Slightly widening of PDL</li> <li>- Lamina Dura discontinuity</li> </ul> <p><u>Histologically:</u></p> <ul style="list-style-type: none"> <li>- Overwhelming purulent (neutrophil) exudate</li> <li>- No Epithelial Wall</li> </ul> <p>If left untreated -&gt; Can lead to Osteomyelitis or cellulitis</p>

## Related Conditions

<b>Osteomyelitis</b> <ul style="list-style-type: none"> <li>- NOT infectious, but is rather inflammatory</li> </ul>	<p>Inflammatory process w/i medullary (trabecular) bone that involves the marrow spaces</p> <p><u>Acute Osteomyelitis:</u></p> <ul style="list-style-type: none"> <li>- Rapid destructive inflammatory process w/i bone that consists of granulation tissue, purulent exudate, and islands of non-vital bone (Sequestra)</li> </ul> <p><u>Chronic osteomyelitis:</u></p> <ul style="list-style-type: none"> <li>- Induces bone to form and become more dense</li> </ul>
<b>Periodontitis Complex (Perio-Endo Lesion)</b>	<p>Periapical pathology extends to involve the gingival sulcus -&gt; Causes perio issues</p> <ul style="list-style-type: none"> <li>- Periodontitis extends down to involve apical tissue</li> </ul>

## Mimics of Periapical Lesions

- Ameloblastomas
- Odontogenic Keratocyst
- Lateral periodontal cysts -> Mimics lateral radicular cysts
- Periapical cemental dysplasia -> Mimics periapical disease
- Langerhan's cell histiocytosis -> Neoplastic proliferation of histiocytic cells, presenting as a periapical lesion

## Clinical Applications: Exam and Dx

### 5 Stages of Dx:

1. Patient States their issue
  - Chief Complaint -> LOPQRSTAAA
2. Clinician questions about symptoms + Hx
  - Med Hx
  - Dental Hx
3. Clinician performs objective clinical tests
  - Pulp and Periapical Tests
  - Clinical Exam (EOE, IOE)
  - Radiographs
  - Additional tests (Transillumination, Selective Anesthesia, Cavity Test)
4. Correlate objective and subjective findings -> Generate dDx
5. Formulate a definitive Dx

## Testing

Periapical testing		
<b>Palpation</b>	<p>*Firm digital pressure to the mucosa covering the roots and apices*</p> <ul style="list-style-type: none"> <li>- Assess <u>texture, rigidity, tenderness</u></li> <li>- Identify areas of swelling</li> <li>- Tenderness to palpation <b>compared to contralateral side</b></li> </ul>	
<b>Percussion</b>	<p>*Individually percussing teeth using the back of the mirror handle*</p> <ul style="list-style-type: none"> <li>- Inflamed PDL very tender -&gt; start with light pressure</li> <li>- Start with least suspected tooth as a control/normal</li> <li>- Tap both laterally and vertically</li> </ul> <p>**Pain on percussion doesn't indicate vitality of tooth -&gt; Rather its an indication of inflammation in the PDL**</p> <ul style="list-style-type: none"> <li>- Could be trauma, high filling, or ortho Tx causing the inflammation</li> </ul>	
<b>Bite Test</b>	<p>*Tooth Slooth placed on occlusal aspect of tooth, Pt bites down on stick. Place on different cusp and repeat*</p> <ul style="list-style-type: none"> <li>- Tooth may be sensitive to biting when pulpal pathosis extends to PDL -&gt; Symptomatic apical periodontitis</li> <li>- Tooth may sensitive secondary to a crack in the tooth -&gt; Pain upon release</li> </ul>	

Pulpal Testing					
Cold Test	<p>*Refrigerant spray applied liberally on size #2 cotton pellet -&gt; <b>Pellet placed on cervical 3<sup>rd</sup> of tooth*</b></p> <ul style="list-style-type: none"> <li>- Start on contralateral tooth (ID baseline response)</li> <li>- Focus on the areas that deviate markedly from the baseline (sometimes every tooth is at least a little sensitive)</li> <li>- Fluid flows INTO the tubules -&gt; Stimulates A-<math>\delta</math> fibers in pulp</li> </ul> <p>CO<sub>2</sub> snow is the gold standard -&gt; The colder the test the more reliable it is.</p> <ul style="list-style-type: none"> <li>- Refrigerant spray = -18 on tooth</li> <li>- CO<sub>2</sub> snow = -50 on tooth</li> </ul> <p><u>Responses:</u></p> <ul style="list-style-type: none"> <li>- Lack of Response</li> <li>- Lingering pain after removal</li> <li>- Immediate excruciatingly painful sensation when stimulus is placed</li> </ul> <table border="1"> <thead> <tr> <th>False +ve</th><th>False -ve</th></tr> </thead> <tbody> <tr> <td> <ul style="list-style-type: none"> <li>- Partial pulp necrosis</li> <li>- High Pt anxiety</li> <li>- Ineffective tooth isolation</li> <li>- Contact with metal resto's</li> </ul> </td><td> <ul style="list-style-type: none"> <li>- Calcific canals</li> <li>- Recently traumatized teeth</li> <li>- Immature apex</li> <li>- Pt taking pain meds</li> <li>- Poor contact of pulp tester to tooth</li> </ul> </td></tr> </tbody> </table> <p>*Cold doesn't damage the pulp, but heat does*</p>	False +ve	False -ve	<ul style="list-style-type: none"> <li>- Partial pulp necrosis</li> <li>- High Pt anxiety</li> <li>- Ineffective tooth isolation</li> <li>- Contact with metal resto's</li> </ul>	<ul style="list-style-type: none"> <li>- Calcific canals</li> <li>- Recently traumatized teeth</li> <li>- Immature apex</li> <li>- Pt taking pain meds</li> <li>- Poor contact of pulp tester to tooth</li> </ul>
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Heat Test	<p>*Useful when chief complaint is pain on contact with hot liquid or food*</p> <ul style="list-style-type: none"> <li>- Coat tooth with petroleum jelly and have <b>triplex syringe ready to cool tooth back down</b> (can damage the pulp if heat is excessive)</li> <li>- Activates both A <math>\delta</math> Fibers and C Fibers</li> </ul> <p><u>Things to use:</u></p> <ul style="list-style-type: none"> <li>- Hot water</li> <li>- Heated GP (65°C)</li> <li>- Frictional heat</li> </ul>   				
Electric Pulp Test	<p><b>*Assessment of pulp neural responses*</b></p> <ul style="list-style-type: none"> <li>- Dry the teeth and apply a conducting medium (Toothpaste, TA gel etc)</li> <li>- Have Pt hold the rod to complete the circuit and let go when sensation is felt</li> <li>- Doesn't tell us about the histological health of the pulp, only that some nerves are responding</li> <li>- Number from the EPT only matters if it differs significantly from the control tooth</li> <li>- Most accurate when <b>NO</b> response is obtained to any electricity</li> </ul> 				
Additional Tests					
Perio Exam	<p><u>Mobility</u></p> <ul style="list-style-type: none"> <li>- Mobility of a segment of tooth only indicates fracture or split tooth</li> <li>- ↑ mobility is NOT indication of pulp vitality, rather perio attachment issue</li> </ul> <p><u>Probing</u></p> <ul style="list-style-type: none"> <li>- Depths &gt;4mm signifies possible periodontal attachment loss and may affect overall Dx</li> <li>- Wide spread deep perio probings = perio issue (probably not endo)</li> <li>- Isolated areas of vertical bone loss may be endo -&gt; Non-vital tooth</li> <li>- Acutely inflamed pulps or acute apical abscess may be associated with complained of "tooth feeling elevated" -&gt; Might have fremitus</li> </ul>				
Transillumination	Aids Dx of cracked or fractured teeth – Place fiberoptic probe on lateral surface to visualize crack				
Selective anesthesia	<ul style="list-style-type: none"> <li>- If tricky to localize the source you can selectively freeze a specific tooth or a quad to help identify problem teeth</li> </ul>				
Cavity test	<p>When testing gives inconclusive results -&gt; Can drill a small hole into the lingual surface or occlusal surface w/o freezing.</p> <ul style="list-style-type: none"> <li>- No pain if the pulp is inflamed or necrotic</li> <li>- As bur enter DEJ a vital pulp will feel pain</li> <li>- **Be careful with this! Pretty old test**</li> </ul>				
Vitality Testing					
<ul style="list-style-type: none"> <li>- Direct measure of vascularity</li> </ul>					
Pulse Oximetry	<ul style="list-style-type: none"> <li>- Monitors blood O<sub>2</sub> saturation</li> </ul>				
Laser Doppler Flowmetry	<ul style="list-style-type: none"> <li>- Infra-red light by laser absorbed by RBC and tissue -&gt; light returns to photo detector and quantitates blood flow</li> </ul>				

**This is how the testing should be presented**

Tooth	Percussion	Palpation	Probing	Mobility	Bite	Cold (Hot as needed)	EPT (When applicable)
36	Normal	-	3.4.5 2.1.4	II	+	-	65

- Also **Classify the case base on the CAE classification rubrics** -> Tx plan must be approved by endo consult prior to start of Tx

## UBC Endo Clinic Protocol

<b>Endo Pt Assignment</b>	Endo patients come from IGP Screening, Urgent care, OS, Grad Endo or Faculty clinic -> Once approved from the CA they will be assigned to a student <ul style="list-style-type: none"> <li>- All Tx plans must be swiped by the endo consultant</li> <li>- Endo Sign Up: 6 spaces + 2 Waitlist</li> </ul>																
<b>Booking</b>	<ol style="list-style-type: none"> <li>1. <b><u>Book Pt into IGP</u></b> -&gt; Endo Consult, Tx plan Approved, AND Access <ul style="list-style-type: none"> <li>- Do Med Hx, Dent Hx updates etc over the phone to save time in the chair</li> </ul> </li> <li>2. <b><u>Book Pt into Endo Chair on 2<sup>nd</sup> appointment</u></b> -&gt; Endo Tx may take 1-2 sessions</li> </ol>																
<b>Before Endo Consult</b>	Review CC, Med Hx, Dental Hx etc Complete EO/IE + Endo Testing Review radiographic findings -> 2 PA's, straight and off angled Have Tentative Endo Dx ready Assess restorability and formulate resto Tx plan with IGP/Pros consult																
<b>During Endo Consult</b>	<ul style="list-style-type: none"> <li>- Present clinical findings: CC, Med Hx, Dental Hx, Endo Testing (Accused and adjacent teeth as needed)</li> <li>- Present radiographic findings systematically</li> <li>- Discuss and confirm the Pre-Tx pulpal and periapical Dx</li> <li>- Discuss Endo Tx plan</li> </ul> <p><b>*Restorability of tooth must be determined prior to endo Tx* -&gt; Pros Consult</b></p> <table border="1"> <thead> <tr> <th>Tooth</th><th>Percussion</th><th>Palpation</th><th>Probing</th><th>Mobility</th><th>Bite</th><th>Cold (Hot as needed)</th><th>EPT (When applicable)</th></tr> </thead> <tbody> <tr> <td>36</td><td>Normal</td><td>-</td><td>3.4.5 2.1.4</td><td>II</td><td>+</td><td>-</td><td>65</td></tr> </tbody> </table>	Tooth	Percussion	Palpation	Probing	Mobility	Bite	Cold (Hot as needed)	EPT (When applicable)	36	Normal	-	3.4.5 2.1.4	II	+	-	65
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36	Normal	-	3.4.5 2.1.4	II	+	-	65										
<b>Endo Tx Approval</b>	<b>Requirements:</b> <ul style="list-style-type: none"> <li>- Endo Case Classification (CAE)</li> <li>- Consent for Endo Tx</li> <li>- Endo Tx plan entered and approved</li> </ul> <p><b>*All swipes done before endo Tx is started*</b></p>																
<b>Grading</b>	Endo Grading form to be filled out after the Endo Tx: <ul style="list-style-type: none"> <li>- Patient Docs -&gt; Online Form -&gt; Endodontic Grading Form -&gt; Fill out</li> </ul>																

# CAE Case Classification

## CASE CLASSIFICATION ACCORDING TO THE DEGREES OF DIFFICULTY AND RISK

Criteria and Subcriteria	Average Risk (1 unit/ item)	High Risk (2 units / item)	Very High Risk (5 units / item)
<b>A. PATIENT CONSIDERATIONS</b>			
1. Medical history / anesthesia / patient management	<input type="checkbox"/> No medical problem (ASA Class I)	<input type="checkbox"/> Special attention: pacemaker / antibiotic allergy (ASA Class II) <input type="checkbox"/> Vasoconstrictor intolerance <input type="checkbox"/> Lack of cooperation / fear	<input type="checkbox"/> Complex medical history / serious illness / disability (ASA Classes III and IV*) <input type="checkbox"/> Intolerance to anesthetic <input type="checkbox"/> Resistance to anesthetic
2. Diagnosis	<input type="checkbox"/> Signs and symptoms straight forward : clear diagnosis	<input type="checkbox"/> Differential diagnosis of usual signs and symptoms	<input type="checkbox"/> Confusing and complex signs and symptoms : difficult diagnosis <input type="checkbox"/> Indeterminable diagnosis
3. Mouth aperture and physical limitation	<input type="checkbox"/> Normal mouth aperture (35mm+)	<input type="checkbox"/> Reduced aperture (25-35mm) <input type="checkbox"/> Difficulty holding film	<input type="checkbox"/> Non-functional aperture (-25mm) <input type="checkbox"/> Limited reclusion
4. Radiographic difficulties	<input type="checkbox"/> Average conditions	<input type="checkbox"/> Gagging <input type="checkbox"/> High floor (lower premolars and canines) <input type="checkbox"/> Narrow or low palatal vault	<input type="checkbox"/> Hard to solve superimposed anatomical structures
<b>B. TOOTH CONSIDERATIONS</b>			
5. Position in the arch and inclination	<input type="checkbox"/> Anterior or premolar <input type="checkbox"/> Small inclination (-10°) <input type="checkbox"/> Small rotation (-10°)	<input type="checkbox"/> 1 <sup>st</sup> or 2 <sup>nd</sup> molar <input type="checkbox"/> Moderate inclination (10-30°) <input type="checkbox"/> Moderate rotation (10-30°)	<input type="checkbox"/> 3rd molar <input type="checkbox"/> Extreme inclination (+30°) <input type="checkbox"/> Extreme rotation(+30°)
6. Tooth isolation and access / morphologic aberrations of the crown	<input type="checkbox"/> Normal original crown morphology or adequate restoration <input type="checkbox"/> No pretreatment required for isolation <input type="checkbox"/> Stable clamp	<input type="checkbox"/> Taurodontism / microdens <input type="checkbox"/> Simple pretreatment required for isolation <input type="checkbox"/> Unstable clamp (no retention)	<input type="checkbox"/> Fusion / dens in dente* <input type="checkbox"/> Extensive pretreatment required for isolation <input type="checkbox"/> Impaired access (post / core / broken instrument / amalgam...) <input type="checkbox"/> Porcelain / gold occlusal restoration or crown / splint <input type="checkbox"/> Clamp almost impossible to place
7. Canal and root shapes	<input type="checkbox"/> Canal curvature into L form <input type="checkbox"/> Small or no curvature(-10°) <input type="checkbox"/> Single canal anterior or premolar <input type="checkbox"/> Closed apex	<input type="checkbox"/> Canal curvature into L form <input type="checkbox"/> Moderate curvature (10-30°) <input type="checkbox"/> Molar with 3 canals or less <input type="checkbox"/> Premolar or anterior with 2 canals <input type="checkbox"/> Previously initiated endodontic treatment <input type="checkbox"/> Crown axis different from root axis	<input type="checkbox"/> Canal curvature into C or S form <input type="checkbox"/> Extreme curvature (+30°) <input type="checkbox"/> Molar with 4 canals or more <input type="checkbox"/> Premolar with 3 canals <input type="checkbox"/> Canal subdivision in the apical or middle thirds <input type="checkbox"/> C-shape canal system <input type="checkbox"/> Very long tooth (+30mm) <input type="checkbox"/> Open apex
8. Canal calcifications	<input type="checkbox"/> Wide and clear canal	<input type="checkbox"/> Canal and chamber are visible but quite reduced <input type="checkbox"/> Pulp stones	<input type="checkbox"/> Almost indistinct canal path in part or throughout <input type="checkbox"/> Canal no longer visible*
9. Resorptions		<input type="checkbox"/> Internal resorption (without perforation) <input type="checkbox"/> Apical resorption	<input type="checkbox"/> Internal resorption with perforation* <input type="checkbox"/> External resorption with* / or without perforation
10. Mechanical perforation		<input type="checkbox"/> Supra-osseous root perforation	<input type="checkbox"/> Sub-osseous root perforation*
<b>C. ADDITIONAL FACTORS</b>			
11. Trauma History	<input type="checkbox"/> Uncomplicated crown fracture of mature or immature teeth <input type="checkbox"/> Radicular fracture in apical third <input type="checkbox"/> History of concussion	<input type="checkbox"/> Complicated crown fracture of mature teeth <input type="checkbox"/> Radicular fracture in middle third <input type="checkbox"/> History of subluxation / alveolar fracture	<input type="checkbox"/> Complicated crown fracture of immature teeth <input type="checkbox"/> Radicular fracture in cervical third <input type="checkbox"/> Other luxations / avulsion
12. Retreatment			<input type="checkbox"/> Retreatment
13. Periodontal-endodontic condition			<input type="checkbox"/> Mobility/ pocket / fenestration / dehiscence <input type="checkbox"/> Furcation involvement <input type="checkbox"/> Root resection / hemi-section (expected or done)

\*ASA Class IV, fusion / dens in dente, invisible canal, sub-osseous / resorptive perforation belong to Class 3 automatically.

RESULTS :

Total

15 to 17 units :

Class 1

18 to 25 units :

Class 2

More than 25 units :

Class 3

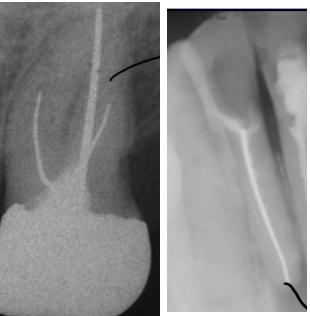
DISPOSITION :

Accepted or  Referred

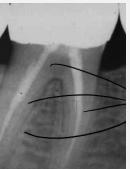
Score	Class	What does this mean at UBC?
<17	1	Suitable for DMD
18-25	2	Suitable for DMD <b>ONLY</b> under instructor approval
>25	3	Refer Refer Refer

# Alternative Filling Materials

## Categories

Solids	Silver Cones		Very Radiodense Very little taper
Semisolids	Gutta Percha, Thermafil, Gutta Core		Medium Radiodensity Noticeable taper Irregularities may be present
Pastes	N2 Pastes -> Hard or soft setting		

## Which is Which?

<b>Relative Radiodensity</b>	Silver Cones > GP, Thermafil > Paste Fillings	
<b>Shape</b>	Silver Cones:	<ul style="list-style-type: none"> <li>- Look like files (w/o the fluting)</li> <li>- Not a ton of taper</li> </ul> 
<b>Irregularities along the obturation</b>		Indicative of a GP, possibly thermoplasticized

## Obturation Techniques

<b>Lateral Compaction</b>	Gutta Percha Cone Formed Cone Technique (Softened GP core with solvent/chloroform)
<b>Vertical Compaction</b>	<p><u>Traditional Technique</u></p> <ul style="list-style-type: none"> <li>- Downpack w/ heated carrier and backfill with segments of cones</li> </ul> <p><u>Downpacking</u></p> <ul style="list-style-type: none"> <li>- Heated carrier and condenser</li> <li>- Touch and Heat and condenser</li> <li>- System B</li> </ul> <p><u>Backfilling with softened GP</u></p> <ul style="list-style-type: none"> <li>- Ultrafil</li> <li>- Obtura</li> <li>- Calamus</li> <li>- Hot Shot (Cordless GP gun)</li> </ul>

<b>Gutta Percha on a Carrier</b>	<u>Metal Carrier</u> <ul style="list-style-type: none"> <li>- Thermafil</li> </ul> <u>Plastic Carrier</u> <ul style="list-style-type: none"> <li>- Thermafil</li> <li>- Densfil</li> <li>- ProSystem GT Obturators</li> <li>- ProTaper Obturators</li> </ul>			
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #f2e0d2;"> <th style="text-align: center; padding: 5px;">Pros</th> <th style="text-align: center; padding: 5px;">Cons</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;"> <ul style="list-style-type: none"> <li>- Promotes minimal shaping (Conservative)</li> <li>- Evidence supports a superior fill</li> <li>- Great for difficult anatomy</li> </ul> </td> <td style="padding: 5px;"> <ul style="list-style-type: none"> <li>- Hard to Re-treat or remove material</li> <li>- Difficult to create post space (Need to drill it out)</li> </ul> </td> </tr> </tbody> </table> <p><u>Crosslinked GP Core</u></p> <ul style="list-style-type: none"> <li>- Gutta Core (Grey color)</li> <li>- CuttaCore Pink</li> </ul>	Pros	Cons	<ul style="list-style-type: none"> <li>- Promotes minimal shaping (Conservative)</li> <li>- Evidence supports a superior fill</li> <li>- Great for difficult anatomy</li> </ul>
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## GuttaCore

<b>Advantages</b>	<ul style="list-style-type: none"> <li>- Centrally condenses the surrounding flowable GP and moves warm flowable GP to Apex</li> <li>- Easy Removal</li> </ul>																																																				
<b>Handle Removal</b>	Bend handle to either side of the canal wall -> Don't affect the seal though!																																																				
<b>Post Space and Retreatment</b>	Very simple. Material is easily removed with a GG																																																				
<b>Clinical Technique</b>																																																					
<b>Shaping</b>	<p>Flare the canal coronally using an orifice shaping instrument Irrigate and dry using a paper point</p> <table border="1" style="margin-top: 10px; border-collapse: collapse; width: 100%;"> <thead> <tr> <th style="text-align: left; padding: 2px;">.04 Final Shape</th> <th style="text-align: left; padding: 2px;">Obturator</th> <th style="text-align: left; padding: 2px;">.06 Final Shape</th> <th style="text-align: left; padding: 2px;">Obturator</th> </tr> </thead> <tbody> <tr><td style="text-align: left; padding: 2px;">20/.04</td><td style="text-align: left; padding: 2px;">Too Small</td><td style="text-align: left; padding: 2px;">20/.06</td><td style="text-align: left; padding: 2px;">20</td></tr> <tr><td style="text-align: left; padding: 2px;">25/.04</td><td style="text-align: left; padding: 2px;">20</td><td style="text-align: left; padding: 2px;">25/.06</td><td style="text-align: left; padding: 2px;">25</td></tr> <tr><td style="text-align: left; padding: 2px;">30/.04</td><td style="text-align: left; padding: 2px;">25</td><td style="text-align: left; padding: 2px;">30/.06</td><td style="text-align: left; padding: 2px;">30</td></tr> <tr><td style="text-align: left; padding: 2px;">35/.04</td><td style="text-align: left; padding: 2px;">30</td><td style="text-align: left; padding: 2px;">35/.06</td><td style="text-align: left; padding: 2px;">35</td></tr> <tr><td style="text-align: left; padding: 2px;">40/.04</td><td style="text-align: left; padding: 2px;">35</td><td style="text-align: left; padding: 2px;">40/.06</td><td style="text-align: left; padding: 2px;">40</td></tr> <tr><td style="text-align: left; padding: 2px;">45/.04</td><td style="text-align: left; padding: 2px;">40</td><td style="text-align: left; padding: 2px;">45/.06</td><td style="text-align: left; padding: 2px;">45</td></tr> <tr><td style="text-align: left; padding: 2px;">50/.04</td><td style="text-align: left; padding: 2px;">45</td><td style="text-align: left; padding: 2px;">50/.06</td><td style="text-align: left; padding: 2px;">50</td></tr> <tr><td style="text-align: left; padding: 2px;">55/.04</td><td style="text-align: left; padding: 2px;">50</td><td style="text-align: left; padding: 2px;">55/.06</td><td style="text-align: left; padding: 2px;">55</td></tr> <tr><td style="text-align: left; padding: 2px;">60/.04</td><td style="text-align: left; padding: 2px;">55</td><td style="text-align: left; padding: 2px;">60/.06</td><td style="text-align: left; padding: 2px;">60</td></tr> <tr><td style="text-align: left; padding: 2px;">70+/.04</td><td style="text-align: left; padding: 2px;">60</td><td style="text-align: left; padding: 2px;">70+/.06</td><td style="text-align: left; padding: 2px;">70</td></tr> <tr><td style="text-align: left; padding: 2px;">80+/.04</td><td style="text-align: left; padding: 2px;">70</td><td style="text-align: left; padding: 2px;">80+/.06</td><td style="text-align: left; padding: 2px;">80</td></tr> <tr><td style="text-align: left; padding: 2px;">90+/.04</td><td style="text-align: left; padding: 2px;">80</td><td style="text-align: left; padding: 2px;">90+/.06</td><td style="text-align: left; padding: 2px;">90</td></tr> </tbody> </table> <p style="color: red; font-weight: bold; margin-top: 10px;"><i>*Minimum Final Shape: #25 .04 taper*</i></p> <p style="color: red; font-weight: bold; margin-top: 10px;">NOTE: If you are using a 0.04 Taper, then your obturator of choice will be one size smaller</p> <ul style="list-style-type: none"> <li>- If using a 0.06 taper than the obturator will be the same size as your file</li> </ul>	.04 Final Shape	Obturator	.06 Final Shape	Obturator	20/.04	Too Small	20/.06	20	25/.04	20	25/.06	25	30/.04	25	30/.06	30	35/.04	30	35/.06	35	40/.04	35	40/.06	40	45/.04	40	45/.06	45	50/.04	45	50/.06	50	55/.04	50	55/.06	55	60/.04	55	60/.06	60	70+/.04	60	70+/.06	70	80+/.04	70	80+/.06	80	90+/.04	80	90+/.06	90
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<b>Size Verification</b>	<ol style="list-style-type: none"> <li>1. Confirm WL</li> <li>2. Rotate Obturator in canal to ensure passive fit</li> <li>3. Irrigate the canal</li> <li>4. Dry with paper point</li> </ol>																																																				
<b>Apply Sealer to Canal</b>	<p>Use Paper point and apply a very light coating of sealer</p> <ul style="list-style-type: none"> <li>- Blot with clean paper point after</li> </ul> <p style="color: red; font-weight: bold; margin-top: 10px;">*If you apply too much then it will exude out of the canal into the bone -&gt; Very painful on biting*</p>																																																				
<b>Obturator Placement</b>	<p>Place obturator into canal in 1 smooth continuous motion</p>  <ul style="list-style-type: none"> <li>- Don't use excessive force -&gt; Pressure should follow obturator direction into canal</li> <li style="color: red; font-weight: bold;">**Place paper point in any unfilled canal until that canal is ready for obturation**</li> </ul>  <p style="color: red; font-weight: bold; margin-top: 10px;">Once the GuttaCore is heated, you have <b>8 seconds</b> to place it in the canal before it cools off too much</p> <ul style="list-style-type: none"> <li>- Or this happens</li> </ul>																																																				
<b>Handle Removal</b>	<p>Bend the obturator from side to side to snap off the application handle</p> <ul style="list-style-type: none"> <li>- Use a round bur or inverted cone bur in high speed handpiece to cut out extra</li> </ul>																																																				
<b>Removing material</b>	<p>Use a rotary or reciprocating file of the same size as the last file taken to working length</p> <ul style="list-style-type: none"> <li>- If needed can use a file to soften the GP around the core as needed</li> </ul>																																																				

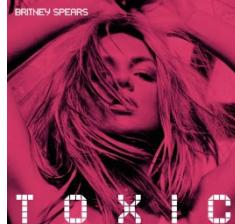
### Clinical Steps to Obturate with Gutta Core

1. Final Rinse with Qmix
2. Irrigant activation with Endo Activator
3. Dry canal with paper points
4. Use Size Verifier to working length
5. Apply sealer to canal
6. Blot excess sealer with paper point
7. Insert GuttaCore Obturator -> 5 sec insertion into canal

#### Essentials

- 1. Wave One Motor (X-SMART IQ) +
- 2. W1Gold files, W1GoldGlider (W1GG)
- 3. Endo Activator and Q-Mix
- 4. ProRinse needles ( 30 gauge side-vented)
- 5. GuttaCore oven + GuttaCore

## Paste Fills

<b>Sargent Paste -&gt; N2</b>	<p>This dude thought that his paste would replace the nerve....It is actually brutal and toxic</p> <ul style="list-style-type: none"> <li>- Paste can get into IAN canal and cause paresthesia</li> </ul> <p>Ingredients:</p> <ul style="list-style-type: none"> <li>- Paraformaldehyde (6.5%)</li> <li>- Lead Oxide</li> <li>- Phenylmercuric Boride</li> </ul> <p>= SO FUCKING TOXIC</p>	
<b>Disadvantages of Pastes</b>	<ul style="list-style-type: none"> <li>- Cytotoxic to periradicular tissues</li> <li>- Washout of the canal space over time -&gt; Poor seal</li> <li>- Hard setting pastes are very hard to remove</li> <li>- Difficult to control the length of obturation</li> <li>- Easy to get voids during placement</li> <li>- Tend to leak</li> <li>- Hard to create a post space</li> </ul>	

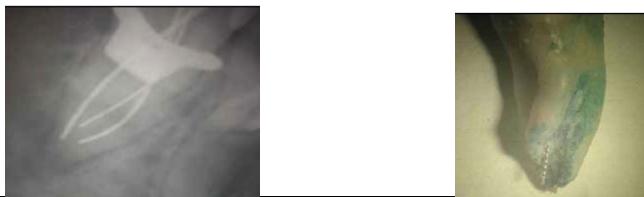
## Silver Cones

<b>Disadvantages</b>	<p>Zinc Phosphate Cements used will wash out -&gt; Creates corrosion of the silver cone</p> <ul style="list-style-type: none"> <li>- Corrosion products are toxic to peri radicular tissues</li> </ul> <p>Difficult to create post space</p> <p>Can be hard to retrieve from the canal</p> <ul style="list-style-type: none"> <li>- For the love of god don't cut off the hook at the top of the cone...these are used for retrieval</li> </ul>
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Clinical Situation	Sargent Method	Traditional Method (GP, Silver Cones)
Canal Preparation	Uses engine driven reamers to full WL	Hand and mechanized instruments to shape canal
Use of NaOCL or other irrigants	Nope	Heavy use to dissolve necrotic debris, lubricate and disinfect the canal
Radiographic verification of WL/Depth of prep	No (Poor length control)	Always used
Filling Materials	Paste with paraformaldehyde to give off constantly nascent formaldehyde - Also contains lead salts	GP or Silver cones + Sealer
Solvent to dissolve	No known solvent	Chloroform for GP + Sealer
Frequency in changes of composition	Many changes in formulations	Same formulation, consistent
Surgical Tx	Fistulator used to complete "gangrenous teeth" in 1 appointment - Don't google "Fistulator" you might regret it	Occasionally needed

# Apex Locators

Determination of Root Canal Lengths

<b>Radiographic</b>	<p><b>*Most Important* -&gt; MUST has good pre-op films</b></p> <ul style="list-style-type: none"> <li>- Pre and Post op films are required (Parallel and bisecting techniques used)</li> <li>- Estimates length of canals</li> </ul> <p><b>Accuracy is variable</b> (due to foreshortening or elongation distortion)</p> <ul style="list-style-type: none"> <li>- Files at radiographic apex are usually longer than they appear (this is part of the reason why we stop short of the apex)</li> <li>- &gt;50% of files placed at radiographic apex are 1mm long!</li> </ul> <p>Looks Reasonable -----&gt; NOPE, you actually fucked up</p> 
<b>Anatomical Tooth Lengths</b>	<p><b>Extremely poor technique to use</b></p> <ul style="list-style-type: none"> <li>- Tooth lengths are averaged from studies, but obviously teeth don't read textbooks and will be as long or short as they damn well please</li> </ul>
<b>Tactile</b>	<p>Need to have great touch</p> <ul style="list-style-type: none"> <li>- Ultrathin Durex gloves....for your Endodontists pleasure 😊</li> </ul>
<b>Periodontal Sensitivity</b>	<p><b>Painful method...intentionally poke a file through the apex until they feel pain</b></p> <ul style="list-style-type: none"> <li>- If there is vital tissue in the canal then they will feel pain short of the working length (False positive)</li> </ul>
<b>Blood on paper points</b>	<p>Can either be too short and perfed, or too long and in the apical tissues</p>
<b>Electronic Means (Apex Locators)</b>	<p><b>Most Accurate (97% accurate)</b></p>

## Electronic Apex Locators

<b>How do they work?</b>	<p>Older Models -&gt; <u>Electrical Resistance</u></p> <ul style="list-style-type: none"> <li>- Narrow apical constriction produces an electrical resistance gradient which is constant</li> <li>- This doesn't work though when the foramen is large or if the canals are filled with electrolytes</li> <li>- Sensitive to canal contents and irrigants</li> </ul> <p>Newer Models -&gt; <u>Electrical Resistance</u></p> <ul style="list-style-type: none"> <li>- Updates have included 2 different frequencies used and the machine measures the impedance difference</li> </ul>
<b>1<sup>st</sup> Generation</b> - Endodontic Meter	<p><u>Theory:</u></p> <ul style="list-style-type: none"> <li>- Electrical resistance btwn periodontium at the base of the gingival crevice and a reference point on the oral mucosa is constant -&gt; This resistance is the same between the PDL at the apical foramen and the mucosal reference</li> </ul> <p><u>How it worked</u></p> <ul style="list-style-type: none"> <li>- Measured the resistance to the flow of direct current</li> <li>- Needs to be fully dry or the fluid will conduct the current above the actual foramen location</li> </ul>
<b>2<sup>nd</sup> Generation</b> - Sono-Explorer - Apex Finder - Digipex - Foramatron IV	<p><u>How they work:</u></p> <ul style="list-style-type: none"> <li>- Impedance apex locators again, measuring the resistance to current flow</li> <li>- Again the canal must be free of electroconductive materials for accurate measures</li> </ul>
<b>3<sup>rd</sup> Generation</b> - Root ZX - Endex - Apex Finder A.F.A - Neosono Ultima Ez	<p><u>How they Work:</u></p> <ul style="list-style-type: none"> <li>- 2 current sources w/ differing frequencies used to measure the impedance of the canal</li> <li>- <u>Root ZX</u> = 8 + 0.4 kHz</li> <li>- <u>Endex</u> = 5 + 1 kHz</li> </ul>
<b>4<sup>th</sup> Generation</b> - Bingo - Elements Diagnostic Unit	<p><u>How they work:</u></p> <ul style="list-style-type: none"> <li>- Uses one of its 2 frequencies at a time -&gt; Compares the resistance and capacitance against a database to determine the distance between the file and the apex</li> </ul>

<b>Components of the machine</b>	<ol style="list-style-type: none"> <li>1. The unit itself</li> <li>2. Lip Clip</li> <li>3. File Clip or Probe</li> <li>4. Cord connecting all 3 together</li> </ol> 
<b>Contraindications for Use</b>	<ul style="list-style-type: none"> <li>- <b>Pacemakers -&gt; Ask cardiologist before using</b></li> </ul>
<b>Indications</b>	<ul style="list-style-type: none"> <li>- <b>Routine Endo cases</b></li> <li>- <b>Unclear radiographic apices</b></li> <li>- <b>↓ number of radiographs -&gt; Don't need a WL film as long as you state in your notes that you used an apex locator to determine WL</b></li> <li>- <b>Gagging patients that can't handgraphs</b></li> <li>- <b>Perforations -&gt; Will read 0 immediately 😞</b></li> <li>- <b>Retreatments</b></li> </ul>
<b>Clinical Technique</b>	<ol style="list-style-type: none"> <li>1. <b>Provisional Working Length determination (Pre-Op Radiograph)</b></li> <li>2. <b>Begin Crown-Down Prep</b></li> <li>3. <b>Irrigation</b></li> <li>4. <b>Use EAL to get true WL</b></li> <li>5. <b>Take Radiograph to confirm length and visualize root shape and canal direction</b> <ul style="list-style-type: none"> <li>- This is a bit redundant...but some instructors make us do it mostly to get practice taking difficult radiographs</li> </ul> </li> </ol>
<b>Causes of inaccurate readings</b>	<ul style="list-style-type: none"> <li>- <b>Files contacting metal</b> (move file away from access cavity walls containing metal)</li> <li>- Presence of <b>conductors</b> (Exudate, blood, irrigant contacting metal)</li> <li>- Poor quality control in <b>cheaper models</b> (use 3<sup>rd</sup> gen. or newer)</li> <li>- <b>Weak batteries</b> (Change if 50% battery or below)</li> <li>- <b>Incompletely formed Apex</b> (Apexification type cases) -&gt; Use a file to determine WL radiographically</li> <li>- File used to measure working length is much smaller than apical construction -&gt; Choose a larger file to approximate the width of the constriction</li> </ul>

#### Root ZX

- Uses **multiple Frequencies** and impedance to determine the apical constriction. A microprocessor in the unit compares the ratio of those frequencies as the instrument travels apically
- When the ratios match to a certain frequency that indicates a constriction in the canal
- **At the 0.5 unit reading = File approximates the apical constriction (minor diameter). This is the appropriate WL**
  - Best to go all the way to a reading of "0" and then back up the file to "0.5"

**Pro Tip:** Tell Pt you are using a machine to determine the length electronically so they don't freak out when it starts "flat lining"

# Retreatment Vs Microsurgery

## Prognosis Vs Outcome

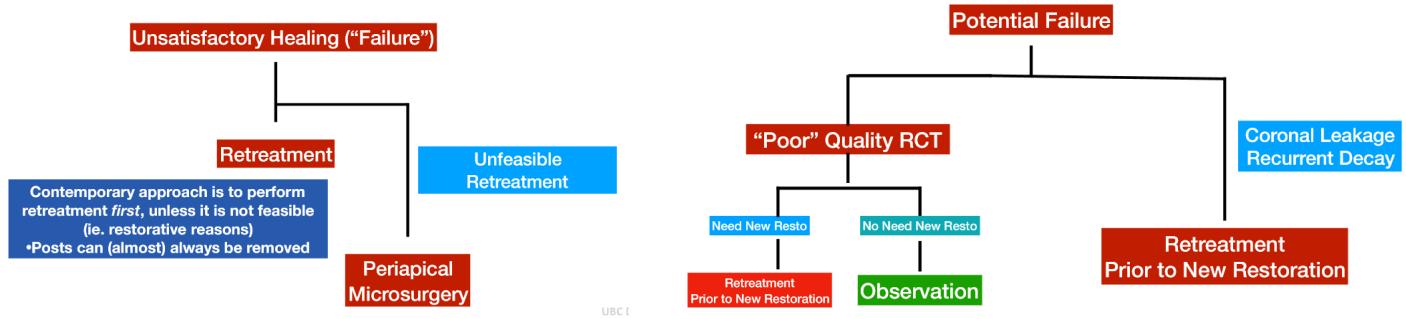
<b>Prognosis</b>	= Practitioner's assessment about how a patient will recover from an illness or injury. - A forecast of the probable course of recovery for a particular disease In Endo some prognostic factors are universal to all cases and some are variable case to case
<b>Outcome</b>	= The end result of Tx and a consequence of Tx decisions made
<b>What is considered an Endo Success?</b>	
	- Absence of pain - Tooth is functional - Soft Tissues appear normal
<b>Outcome Classification</b>	
<b>Healed</b>	Both clinical and radiographic presentations are normal - Healed rate of >92% if done properly and appropriately restored - Healing rate of RCT + Apical microsurgery is ~99%
<b>Healing</b>	Dynamic process over time -> ↓ radiolucency + Normal clinical presentation - Evaluation @ 6mo, 1yr, 2yr, 3yr, 4yr
<b>Disease (Non-healing)</b>	No chance or ↑ Radiolucency over time + Symptomatic clinically
<b>Factors Affecting the Outcome</b>	
<ul style="list-style-type: none"> <li>- Diagnostics</li> <li>- Lack of knowledge of canal anatomy</li> <li>- Inadequate Debridement</li> <li>- Operative errors</li> <li>- Obturation errors</li> <li>- Inadequate restoration/Coronal leakage</li> </ul>	
<b>Pre-Operative</b>	<ul style="list-style-type: none"> <li>- Incorrect Dx</li> <li>- Poor case selection (Use the case difficult assessment)</li> <li>- Pre-Existing Conditions (Pulp status, Trauma, Endo-Perio, Resorption, Previous endo)</li> </ul>
<b>Intra-Operative</b>	<ul style="list-style-type: none"> <li>- Failure to achieve biologic objectives (Poor debridement, Poor obturation)</li> <li>- Failure to achieve mechanical objectives (not preserving tooth structure)</li> <li>- Operator Errors (Ledges, Blocked canals, Perforation, Separated Instrument)</li> </ul>
<b>Post-Operative</b>	<ul style="list-style-type: none"> <li>- Inadequate Final Resto <ul style="list-style-type: none"> <li>- Posterior teeth need cuspal protection</li> <li>- Inadequate coronal seal (exposure to saliva, recontamination of canals)</li> </ul> </li> </ul>

## Methods for Evaluating Outcome (Success vs. Failure)

- The cause of Endo failure is due to the presence of bacterial infection inside (and sometimes outside the root canal system)

<b>Clinical Criteria</b>	Asymptomatic -> Normal subjective findings No tenderness to percussion or palpation -> Normal objective Soft Tissues are normal -> Colour, Contour, Texture Normal Perio probings Healing of pre-existing swelling/sinus tract  <b>**Normal Function, Appearance and the absence of symptoms do not always mean the absence of infection**</b>
<b>Radiographic Criteria</b>	Normal PDL Space Normal Lamina Dura ↓ or elimination of previous rarefaction Resorption has arrested Root filling is radiodense with no voids and is to the proper length  <b>**Patient can be symptomatic even w/ normal radiographic findings, and vice versa**</b>
<b>Histologic Criteria</b>  <b>(The gold standard, but not clinically practical)</b>	Absence of bacteria Absence of inflammatory cells Regeneration/Repair of the PDL Regeneration/Repair of bone

## Retreatment Vs Apical Microsurgery



Retreatment	
<b>Risks:</b>	<ul style="list-style-type: none"> <li>- Ceramic Fracture or <b>damage to existing crown</b></li> <li>- Crown dislodgement (Pre-Existing issues/recurrent carries)</li> <li>- <b>Root fracture</b> when removing post</li> <li>- <b>Perforation</b></li> <li>- <b>Unable to attain desired length</b> (previously ledged, blocked, transported canals)</li> <li>- Non-resolved lesion (Strange anatomy, Extra-radicular infection, True Cyst)</li> </ul>
<b>Advantages</b>	<ul style="list-style-type: none"> <li>- Less invasive (no surgery)</li> <li>- Best Tx for missed canal or inadequately cleaned canal system</li> <li>- Minimize bacteria in unclean or recontaminated canal system</li> <li>- Indirect assessment of microleakage</li> </ul>
Apical Microsurgery	
<b>Risks</b>	<ul style="list-style-type: none"> <li>- Anatomical Structure</li> <li>- Surgical complication</li> <li>- Shortened roots</li> <li>- Gingival recession</li> <li>- Unable to clean bacteria remaining in the canal system</li> </ul>
<b>Advantages</b>	<ul style="list-style-type: none"> <li>- 1 visit</li> <li>- Can get a tissue sample for biopsy (determine if it's a cyst)</li> <li>- Visualize root fracture</li> <li>- Remove apical aberrations, Extra-radicular infection, cysts etc</li> </ul>

### Which Do we Choose?

Contemporary approach: Attempt non-surgical retreatment 1<sup>st</sup>

- Apical microsurgery is the 1<sup>st</sup> option ONLY if the non-surgical retreatment is contraindicated
- On occasion, revision therapy will sometimes need to involve both Tx options

## Restoration of Endodontically Treated Teeth

- 60% of Endo failure is due to poor prosthetics! Only 8% is actually due to the endo itself.

### Contamination occurs:

- During Endo Tx
- During post space preparation
- Coronal leakage from temporary resto
- Coronal leakage from permanent resto after Endo Tx



\*\* Its critical that there is a good rubber dam seal! Use Light Cure "Cool Dam" (available at Dispensary) to seal the dam and ensure the area is completely isolated\*\*

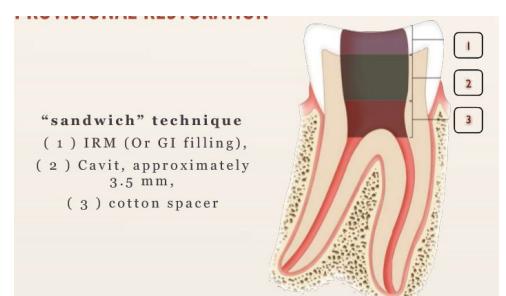
**Temporary Fills**

Cavit is a temporary material and usually **only** lasts about 2-3 weeks

- Fill with Cavit + Cap with GI

Cavit = Provides a good seal of the access

GI = Provides Strength to withstand occlusion

<b>Before RCT</b>	<ul style="list-style-type: none"><li>- Assess tooth for:<ul style="list-style-type: none"><li>o Restorability</li><li>o Occlusal Function</li><li>o Periodontal Health</li><li>o Biological Width</li><li>o C:R Ratio</li></ul></li><li>- Remove all existing restorations and caries to accurately assess restorability and assess for fractures</li><li>- Consider crown lengthening</li></ul>
<b>After RCT</b>	<p><b>Preventing contamination is #1 concern!</b> -&gt; MUST place some sort of immediate resto (Temp or final) to seal everything</p> <ul style="list-style-type: none"><li>- Never delay restorative Tx to assess the success of the Tx... ↑ risk of failure</li></ul> <p>Orifice Barriers:</p> <ul style="list-style-type: none"><li>- Lay down Vitrebond or flowable composite over the canal orifice, and then fill with Permafil Composite (it's purple so it's obvious where the floor is)</li><li>- IRM or Cavit seal well but they should be replaced within a few weeks (They are weak)</li><li>- RMGIC or Composites don't seal as well as Cavit, but they are strong -&gt; Consider layering these ontop of Composite</li></ul> 

### RCT Through existing Crowns

- Be careful! The tooth might be rotated under the crown and might not be at the angulation you think it is. Make sure you probe around the root surface to confirm the shape
- If the crown appears acceptable -> Ensure the absence of recurrent caries before the access opening is restored
  - o If there are caries -> 1<sup>st</sup> choice is to remove the crown completely and clean up the tooth



## Posts

Risk of root fracture ↑ when you use post -> Removal of sound dentin during prep 😞

- Can lead to perforation apically if you are heavy handed, or lateral strip perforation if your angulation is off or the root is thin

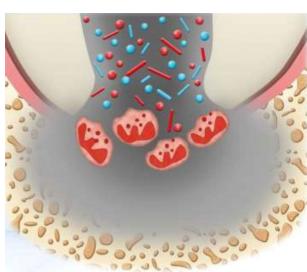
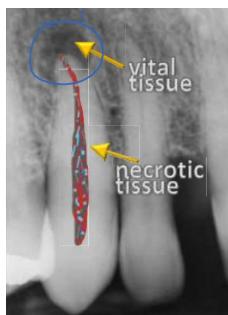
Temporization of Post space?	<p>This is generally a bad idea</p> <ul style="list-style-type: none"> <li>- Perform a post and core buildup immediately so you don't need a temp</li> <li>- If needed, use barrier over GP (GIC)</li> <li>- Place small drop of GIC at the end of the post = seals the GP</li> </ul> <p>Immediate creation of the post space may result in a better apical seal (This really depends on the study that you read though)</p>
Where do we place Posts?	<p><u>Mandibular Molars</u></p> <ul style="list-style-type: none"> <li>- Post should go into <u>the</u> Distal Canal</li> </ul> <p><u>Maxillary Molars</u></p> <ul style="list-style-type: none"> <li>- Post should go into the Palatal Canal</li> </ul> <p>*Other canals are thinner and more curved -&gt; Risky business</p> <ul style="list-style-type: none"> <li>- Avoid multiple posts!</li> </ul>
General Consensus	<p>Remove little (if any) additional dentin beyond what you need for the RCT</p> <ul style="list-style-type: none"> <li>- Retain minimum of 4mm of GP apically -&gt; This maintains the apical seal</li> </ul> <p>Forces concentrate at the crest of bone during function -&gt; Place the post to extend apical to the crest of the bone</p> <ul style="list-style-type: none"> <li>- Post should extend "into bone" at least as far as it protrudes "out of bone"</li> </ul>
Important clinical factors	<p>Amount and quality of remaining tooth structure Anatomic position of the tooth Occlusal forces on the tooth Restorative requirements of the tooth</p> <p>Teeth w/ minimal remaining tooth structure are at risk of:</p> <ul style="list-style-type: none"> <li>- Root fracture</li> <li>- Coronal-apical leakage</li> <li>- Recurrent caries</li> <li>- Dislodgment or loss of the core/prosthesis</li> <li>- Periodontal injury from biologic width invasion</li> </ul>

## Guiding Principles for Restorations

1. Posterior teeth w/ root canal Tx should get cuspal coverage restoration
2. Bonded restorations provide only short-term strengthening of the teeth
3. Anterior teeth w/ minimal loss of tooth structure can be restored conservatively with direct resto's
4. Aim to preserve coronal and radicular tooth structure
5. Purpose of a post is to retain the core buildup
6. Need 2mm of vertical height and 1mm of dentin thickness for adequate ferrule

## Irrigation in Endo

A reminder: If there is periapical involvement (Periapical radiolucency) then the tooth is necrotic and has bacteria in it. This bacteria causes the body to respond with ↑ osteoclastic activity around the apex of the root to "run away" from the impending bacterial invasion.

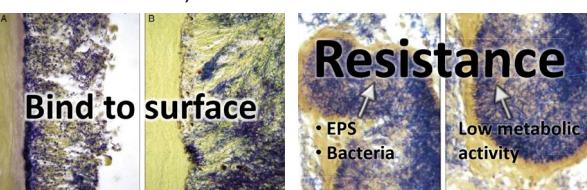
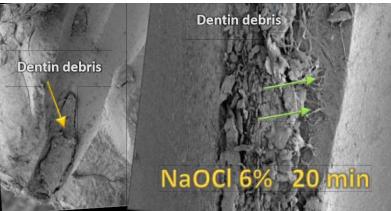
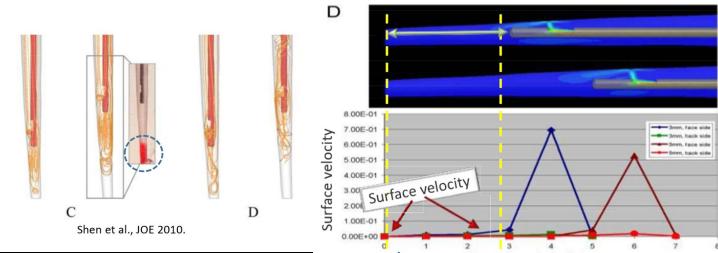


-> This is what we want



There are 3 ways to remove the biofilm in a necrotic pulp:

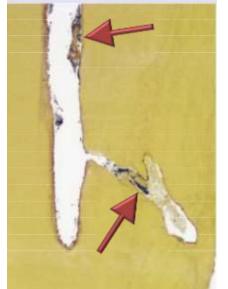
<b>Mechanical</b>	Instrumentation: <ul style="list-style-type: none"> <li>- Provides mechanical cleaning</li> <li>- Creates space for needle</li> <li>- Creates space for disinfection w/ irrigant</li> <li>- Creates space for the root filling material</li> </ul>
<b>Chemical</b>	Irrigation
<b>Energy</b>	?

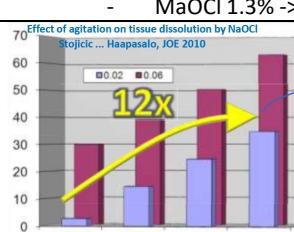
Challenges with Irrigation		
<b>Extracellular Polymeric Substances (EPS)</b>	Polymers secreted by bacteria to create biofilm and attach to the tooth structure <ul style="list-style-type: none"> <li>- Bacteria secreting EPS and in the center of a biofilm tend to have a ↓ metabolic rate, which makes them more resistant to our antimicrobial substances</li> </ul> 	
<b>Dentin Debris</b>	Plugs up the lateral canals and dentinal tubules and prevents irrigant to really penetrate deep and kill all of the bacteria 	
<b>Fluid Hydrodynamics</b>	We can see with these computerized models that <b>not a lot of irrigant actually makes it to the apex when it flows out of the needle</b> We also see <b>very little surface velocity</b> anything less than 3mm from the Apex → Velocity of the fluid is important to disturb the biofilm 	
<b>Risk Spreading the Infection during Endo</b>	 Risk of forcing the bacteria out of the apex	
<b>NaOCl Accident</b>	Extremely painful for the patient. <ul style="list-style-type: none"> <li>- Nothing you can really do other than wait for the pain to die down and the bruising to go away</li> </ul> Caused by forcing NaOCl through the apex of the tooth 	

### Goals of Irrigation

1. Mechanical "washing"
2. Reduce friction
3. Balance Temperature
4. Dissolve Tissue
5. Kill Microbes

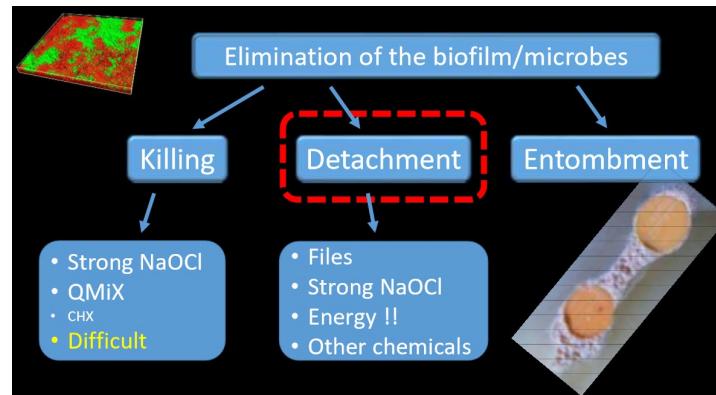
Very Important that we remove the biofilms causing the issue when we are treating endo:

<b>Intracanal Biofilm</b>	<p>There are some areas that might not be accessible by our instrumentation:</p> <ul style="list-style-type: none"> <li>- Fins</li> <li>- Isthmus connecting 2 canals</li> <li>- Lateral Canals</li> <li>- Dentin canals</li> </ul> <p>*Dentin canal bacteria are not the most concerning. If we do an adequate job sealing them away then they will die. It's the main canal bacteria that REALLY need to be removed completely*</p>	
<b>Smear Layer</b>	<p>After instrumenting mechanically we leave behind a smear layer</p> <ul style="list-style-type: none"> <li>- This contains bacteria and cannot be left behind! -&gt; Dissolve with irrigant</li> </ul>	

<b>Which Irrigants should I use?</b>	<u>NaOCl</u> <ul style="list-style-type: none"> <li>- DOESN'T remove the smear layer on instrumented surfaces</li> <li>- DOES remove <b>organic</b> tissue on uninstrumented tissues</li> <li>- Kills microbes</li> </ul> <u>EDTA</u> <ul style="list-style-type: none"> <li>- DOESN'T remove organic material</li> <li>- Removes the smear layer on instrumented surfaces</li> <li>- DOES remove inorganic material</li> </ul> <u>CHX</u> <ul style="list-style-type: none"> <li>- DOESN'T remove the smear layer</li> <li>- DOESN'T dissolve inorganic material</li> <li>- Kills microbes</li> </ul> <u>QMIX:</u> <ul style="list-style-type: none"> <li>- Dissolves inorganic tissues</li> <li>- Kills microbes</li> </ul>			
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center; background-color: #ffd700;">Classic Protocol to follow:</th> <th style="text-align: center; background-color: #ffd700;">New Protocol:</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 5px;">           1. NaOCl            2. EDTA at the end            Optional            3. CHX         </td> <td style="text-align: center; padding: 5px;">           1. NaOCl            2. QMix         </td> </tr> </tbody> </table> <p style="color: red; margin-top: 10px;">**Do not use NaOCl after EDTA**</p> <ul style="list-style-type: none"> <li>- Once EDTA removes the smear layer -&gt; CaPO<sub>4</sub> crystals are exposed and can be dissolved by NaOCl = erosion of the dentin, = weaker structure ☹ **</li> </ul>	Classic Protocol to follow:	New Protocol:	1. NaOCl 2. EDTA at the end Optional 3. CHX
Classic Protocol to follow:	New Protocol:			
1. NaOCl 2. EDTA at the end Optional 3. CHX	1. NaOCl 2. QMix			
<b>How long does it take for irrigant to work?</b>	<p>Depends largely on the Concentration</p> <ul style="list-style-type: none"> <li>- NaOCl 5% -&gt; 1min to remove organics</li> <li>- NaOCl 2.5% -&gt; 5 mins to remove organics</li> <li>- NaOCl 1.3% -&gt; 10 minutes</li> </ul>			
<b>Active Irrigation (Agitation)</b>	<p>Effect of agitation on tissue dissolution by NaOCl Stojicic ... Haapasalo, JOE 2010</p>  <p style="text-align: right; margin-top: 10px;">12x ↑ in effective tissue dissolution w/ constant agitation</p>			

How long does it take irrigants to kill microbes?	<table border="1"> <thead> <tr> <th>Time (min)</th> <th>% Kill</th> </tr> </thead> <tbody> <tr><td>0-3</td><td>18%/min</td></tr> <tr><td>3-10</td><td>3%/min</td></tr> <tr><td>10-30</td><td>0.25%/min</td></tr> </tbody> </table>	Time (min)	% Kill	0-3	18%/min	3-10	3%/min	10-30	0.25%/min	With a 6% NaOCl solution, most of the bacteria were killed within 3 mins, then it levels off as the resistant bacteria take up a greater proportion of the biofilm
Time (min)	% Kill									
0-3	18%/min									
3-10	3%/min									
10-30	0.25%/min									
Mixing irrigants	DON'T YOU DARE <ul style="list-style-type: none"> <li>- NaOCl + EDTA = Inactivated NaOCl</li> <li>- NaOCl + CHX = Mutagenic carcinogen (PCA)</li> <li>- EDTA + CHX = White precipitate</li> </ul>									
Irrigation of the Apical 3 <sup>rd</sup> of the canal	<p><b>Techniques:</b></p> <p><u>GP Technique:</u></p> <ul style="list-style-type: none"> <li>- GP cone all the way down the canal to physically disrupt the biofilm and then irrigate</li> </ul> <p><u>Endo Activator:</u></p> <ul style="list-style-type: none"> <li>- Place activator in the canal w/ irrigant to physically vibrate the fluid deeper</li> </ul> <p><u>PiezoFlow</u></p> <ul style="list-style-type: none"> <li>- Never go to the apical 3<sup>rd</sup> with this because of its active flow + ultrasonic vibration</li> <li>- Its great for getting material in the isthmus of the coronal 3<sup>rd</sup> though</li> </ul> <p><u>Negative Pressure</u></p> <ul style="list-style-type: none"> <li>- Fill the chamber up and suck it back via the needle...works very well!</li> </ul>	Irrigant has a tough time making it all the way to the end and around corners								

Overall Strategy	<ol style="list-style-type: none"> <li>1. Touch the surface (mechanically remove biofilm)</li> <li>2. Irrigate</li> <li>3. Agitate</li> <li>4. Energize</li> <li>5. Dissolve, Clean</li> <li>6. Kill</li> <li>7. Filler + Sealer</li> </ol>
Apical 3 <sup>rd</sup> Aids	<ul style="list-style-type: none"> <li>- Instrument Well</li> <li>- Use side vented needle</li> <li>- Negative pressure</li> <li>- Sonics and Ultrasonics</li> <li>- Laser Activation</li> <li>- Multisonics</li> </ul>



# The Treatment of Traumatic Dental Injuries

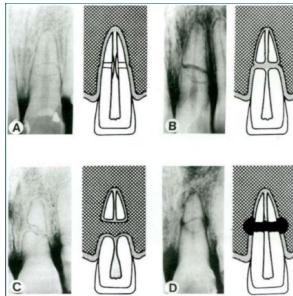
<b>Prevalence:</b>	1/5 Children ; 1/4 Adults <ul style="list-style-type: none"> <li>- Boys 2x &gt; Girls</li> <li>- Peak age 2-4 and 8-10yrs</li> <li>- Hx of Trauma ↑ risk of more trauma 8-fold</li> </ul> <b>Teeth:</b> UI's > LI's		
<b>Etiology</b>	<b>Predisposing Factors</b> <ul style="list-style-type: none"> <li>- ↑ OJ</li> <li>- Protruding Upper Lips</li> <li>- Insufficient Lip closure</li> </ul>	<b>Intentional/Unintentional injuries</b> <ul style="list-style-type: none"> <li>- Physical Abuse</li> <li>- Falls, collisions etc</li> <li>- Sports</li> <li>- Inappropriate use of teeth</li> <li>- Illness, physical limitations</li> </ul>	
	<b>Human Behaviour</b> <ul style="list-style-type: none"> <li>- Risk-Taking</li> <li>- Hyperactivity</li> <li>- Stress behaviour</li> </ul>	<b>Environmental Factors</b> <ul style="list-style-type: none"> <li>- Deprivation</li> <li>- Overcrowding</li> </ul>	

<u>General Management Principles</u>
<ol style="list-style-type: none"> <li>1. Neurological assessment 1<sup>st</sup></li> <li>2. Team Effort (GP + 1+ specialists if needed)</li> <li>3. Aim is to maintain or regain vitality</li> <li>4. Timeline is key to saving the tooth</li> <li>5. Assess difficulty level and refer out if complicated</li> </ol>

## The Examination

<b>History of Trauma</b>	<ul style="list-style-type: none"> <li>- Pt's info</li> <li>- Any CNS symptoms after injury? -&gt; LOC, fluid coming out of ear/nose, Pupillary dilation reflex, Cranial nerve tests <ul style="list-style-type: none"> <li>- <b>NEUROLOGICAL ASSESSMENT is the MOST IMPORTANT thing</b></li> </ul> </li> <li>- General Health</li> <li>- <b>WHEN, WHERE, HOW</b> <ul style="list-style-type: none"> <li>- Keep child abuse as a possibility in your mind</li> </ul> </li> <li>- Any Tx received elsewhere?</li> <li>- Hx of previous trauma</li> <li>- Disturbances to the bite</li> </ul>		
<b>Clinical Exam</b>	<ul style="list-style-type: none"> <li>- E/O, I/O -&gt; Observation + Palpation <ul style="list-style-type: none"> <li>- Check for swelling or tenderness</li> <li>- Midline deviation in appearance and in movement</li> </ul> </li> </ul>  <p>→ These lines represent the most common areas for a mandibular fracture to occur:</p> <ol style="list-style-type: none"> <li>1. Condyle</li> <li>2. Angle of the ramus</li> <li>3. Symphysis</li> </ol>		
<b>Radiographic Exam</b>	<ul style="list-style-type: none"> <li>- Multiple PA angles needed</li> <li>- <b>Occlusal radiograph</b></li> <li>- CBCT Scan</li> </ul> <p>If evidence of laceration -&gt; <b>Soft tissue</b> (usually lip) X-ray to ensure there is no tooth piece lodged in the lip/cheek</p> 		
<b>Vitality Testing</b>	<p><b>*Cold test is generally the most effective vitality test*...HOWEVER</b></p> <ul style="list-style-type: none"> <li>- <b>False negatives are common after injury</b> -&gt; Teeth may not respond to cold for up to 3 yrs after trauma!</li> <li>- Repeat cold test at all recalls</li> </ul> <p><b>*EPT is unreliable in immature teeth*</b></p>		

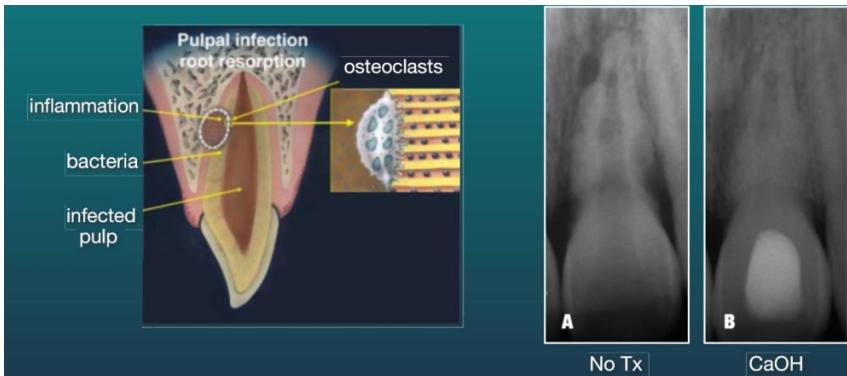
## Injuries

Fractures	
<b>Uncomplicated Crown Fracture</b> 	= No pulpal exposure  <u>Tx:</u> <ul style="list-style-type: none"><li>- Re-attach the fragment -&gt; Just bond it back in place! This is the choice option</li><li>- Restore with composite</li><li>- Restore with veneer/crown</li></ul>
<b>Complicated Crown Fracture</b> 	= With Pulpal Exposure <ul style="list-style-type: none"><li>- Do Pulp vitality testing IMMEDIATELY, and after 6-8 weeks</li></ul> <u>Tx:</u> <ul style="list-style-type: none"><li>- Pulp Capping (Only if a tiny little exposure)</li><li>- Cvek (Partial) Pulpotomy</li><li>- Pulpectomy or RCT</li></ul>  <div style="background-color: yellow; padding: 10px; border: 1px solid black; margin-top: 10px;"><p style="text-align: center;"><b>Cvek (Partial) Pulpotomy</b></p><ol style="list-style-type: none"><li>1. Rubber Dam isolation</li><li>2. Disinfect w/ NaOCl or CHX</li><li>3. Drill 1.5-2mm into pulp (Diamond drill + H<sub>2</sub>O spray)</li><li>4. Place cotton pellet to control the bleeding -&gt; Then wash away the clot</li><li>5. Place White MTA or other bioceramic</li><li>6. Reattach the fragment/place composite/temporary crown</li></ol></div>
<b>Crown-Root Fracture</b> 	Everything really depends on the level of fracture:  <u>Tx Options:</u> <ul style="list-style-type: none"><li>- <b>Exo</b> -&gt; If the fracture is super deep</li><li>- <b>Removal of the coronal fragment</b> -&gt; Do supra-gingival resto</li><li>- <b>Surgical exposure of the fracture surface</b></li><li>- <b>Orthodontic or Surgical extrusion of apical fragment</b></li><li>- <b>Vital root submergence</b></li></ul>
<b>Root Fracture</b> 	<u>Tx:</u> <ol style="list-style-type: none"><li>1. Reposition</li><li>2. Splint (physiologic) -&gt; This could even be as simple as bonding composite btwn the teeth<ul style="list-style-type: none"><li>- <b>Cervical fracture:</b> 4 months</li><li>- <b>Middle fracture:</b> 4wks</li></ul></li><li>3. Adjust occlusion<ul style="list-style-type: none"><li>- Make occlusion very light, or not at all. Don't want to worsen or prolong healing by biting on it</li></ul></li><li>4. Monitor vitality</li></ol> <u>Healing Patterns:</u> <ul style="list-style-type: none"><li>A. Healing w/ calcified tissue</li><li>B. Interposition of PDL</li><li>C. Interposition of bone + PDL</li><li>D. Interposition of granulation tissue -&gt; Non-healing</li></ul>  <u>Endo?</u> <ul style="list-style-type: none"><li>- If the tooth becomes necrotic -&gt; <b>only RCT the coronal segment</b></li><li>- Usually the coronal part loses its vascularity and dies, but the apical part remains ok</li></ul> 

<b>Luxations</b> (From least to most severe)														
<b>Concussion</b> 	<p>= Just a bump on the tooth</p> <p><b>Tx:</b></p> <ol style="list-style-type: none"> <li>1. Rule out fractures</li> <li>2. Adjust occlusion</li> <li>3. Baseline Vitality Testing</li> <li>4. Let it chill</li> </ol>													
<b>Subluxation</b> 	<p>= A bump on the tooth that results in some mobility (but no displacement)</p> <p><b>Tx:</b></p> <ul style="list-style-type: none"> <li>- The same as concussion +</li> <li>- Splint for <b>2 weeks</b></li> </ul>													
<b>Luxations</b>   	<p><b>Intrusive</b> = Displacement of the tooth into the alveolar bone along the axis of the tooth + Communication/fracture of the alveolar socket</p> <p><b>Lateral</b> = Displacement of the tooth into the alveolar bone NOT along the axis of the tooth + Communication/fracture of the alveolar socket</p> <p><b>Tx:</b></p> <ol style="list-style-type: none"> <li>1. Reposition           <ul style="list-style-type: none"> <li>- If the apex of the root is locked between alveolar bone and the fracture...carefully pull the tooth out a bit to release it from the lock and reinsert it into the socket</li> </ul> </li> <li>2. <b>Extrusive?</b> <b>Splint 2 weeks / Lateral? Splint 4 weeks</b></li> <li>3. Follow Up</li> <li>4. Initiate RCT when indicated</li> </ol> <p><b>Intrusive Luxation:</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #FFD700;"> <th colspan="2" style="text-align: center; padding: 2px;">Immature Root</th> </tr> </thead> <tbody> <tr> <td style="width: 30%; padding: 2px;"><b>&lt;7mm movement</b></td> <td style="width: 70%; padding: 2px;"> <ul style="list-style-type: none"> <li>- Wait 3 weeks (monitor signs of re-eruption)               <ul style="list-style-type: none"> <li>- If +ve -&gt; No Tx and monitor</li> <li>- If -ve -&gt; Orthodontic repositioning</li> </ul> </li> </ul> </td> </tr> <tr> <td style="padding: 2px;"><b>&gt; 7mm movement</b></td> <td style="padding: 2px;"> <ul style="list-style-type: none"> <li>- Surgical or orthodontic repositioning <b>WITHIN 3 weeks</b></li> </ul> </td> </tr> <tr style="background-color: #FFD700;"> <th colspan="2" style="text-align: center; padding: 2px;">Mature Root</th> </tr> <tr> <td style="width: 30%; padding: 2px;"><b>&lt;3mm AND Pt &lt;17 yrs</b></td> <td style="width: 70%; padding: 2px;"> <ul style="list-style-type: none"> <li>- Wait for 3 weeks (monitor signs of re-eruption)               <ul style="list-style-type: none"> <li>- If -ve -&gt; Orthodontic extrusion, extraction/re-implantation</li> </ul> </li> </ul> </td> </tr> <tr> <td style="padding: 2px;"><b>&gt;3mm</b></td> <td style="padding: 2px;"> <ul style="list-style-type: none"> <li>- Surgical or orthodontic repositioning <b>WITHIN 3 weeks</b></li> </ul> </td> </tr> </tbody> </table>	Immature Root		<b>&lt;7mm movement</b>	<ul style="list-style-type: none"> <li>- Wait 3 weeks (monitor signs of re-eruption)               <ul style="list-style-type: none"> <li>- If +ve -&gt; No Tx and monitor</li> <li>- If -ve -&gt; Orthodontic repositioning</li> </ul> </li> </ul>	<b>&gt; 7mm movement</b>	<ul style="list-style-type: none"> <li>- Surgical or orthodontic repositioning <b>WITHIN 3 weeks</b></li> </ul>	Mature Root		<b>&lt;3mm AND Pt &lt;17 yrs</b>	<ul style="list-style-type: none"> <li>- Wait for 3 weeks (monitor signs of re-eruption)               <ul style="list-style-type: none"> <li>- If -ve -&gt; Orthodontic extrusion, extraction/re-implantation</li> </ul> </li> </ul>	<b>&gt;3mm</b>	<ul style="list-style-type: none"> <li>- Surgical or orthodontic repositioning <b>WITHIN 3 weeks</b></li> </ul>	
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<b>Avulsion</b>	<p>= Tooth fully came out</p> <p><b>Key Factors affecting prognosis:</b></p> <ul style="list-style-type: none"> <li>- Survival of the PDL Cells</li> <li>- Dry time (time out of the socket)           <ul style="list-style-type: none"> <li>- High survival rate if reimplanted w/i 15-30mins</li> </ul> </li> </ul> <p><b>Emergency Tx:</b></p> <ol style="list-style-type: none"> <li>1. Reimplant immediately</li> <li style="text-align: center;">OR</li> <li>1. Place in a storage medium (Cold milk is usually available at home)</li> <li>2. ONLY handle the crown of the tooth -&gt; keep those PDL cells untouched</li> <li>3. Gently rinse the dirt or whatever off the root and the socket</li> <li>4. Replant and <b>splint for 2 weeks</b></li> <li>5. If &gt;8-12yrs: CHX, Doxycycline, Tetanus booster</li> <li>6. Initiate RCT in 10-14 days</li> </ol>													

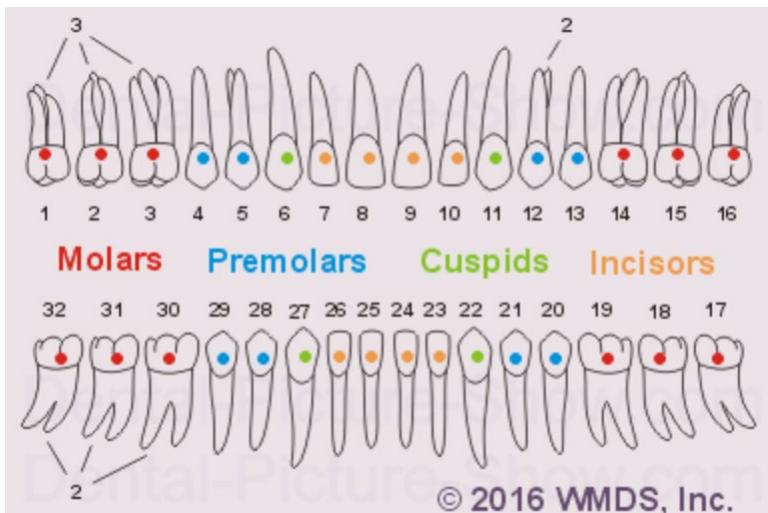
Type of Injury	Splinting Time
Subluxation	2 weeks
Extrusive luxation	2 weeks
Avulsion	2 weeks
Lateral luxation	2 weeks
Intrusion	4 weeks
Root fracture (middle 1/3)	4 weeks
Alveolar fracture	4 weeks
Root fracture (cervical 1/3)	4 months

### Inflammatory Resorption Tid Bit



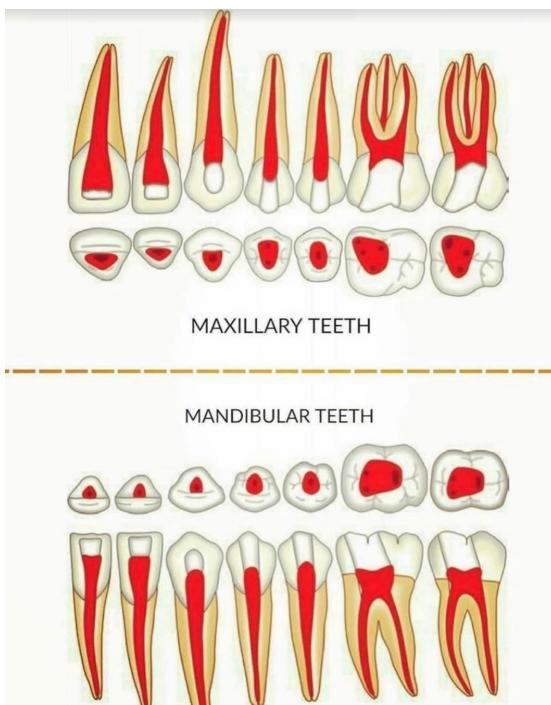
## Appendix

### # of Roots and Canals around the mouth



	Tooth Type	Teeth #'s	Usual # of Roots	Usual # of Root Canals (Total for the tooth.)
Upper	Incisors	7,8,9,10	1	1
Upper	Canines	6,11	1	1
Upper	1st Premolars	5,12	2	2
Upper	2nd Premolars	4,13	1, possibly 2.	1, possibly 2.
Upper	Molars	1,2,3,14,15,16	3	3, probably 4 or more.
Lower	Incisors	23,24,25,26	1	1, possibly 2.
Lower	Canines	22,27	1	1
Lower	Premolars	20,21,28,29	1	1, possibly 2.
Lower	Molars	17,18,19,30,31,32	2	3, possibly 4 or more.

### Average Access Cavities around the mouth:



- Lower molars - It's expected that the front (mesial) root of a lower molar (especially a 1st molar) will have 2 canals. It's not uncommon that the back (distal) root will have 2 too.
- Upper 2nd premolars - In the case that this tooth just has a single root, it's very common for it to have 2 canals.
- Upper molars - It's common for the front (mesial) root of an upper molar (especially a 1st molar) to have 2 canals.
- Lower central and lateral incisors - The single root of a lower incisor sometimes has 2 canals.