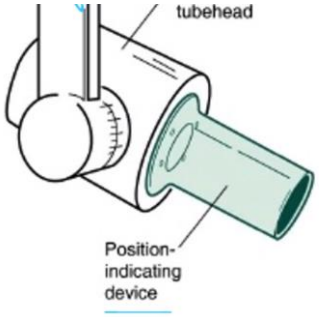
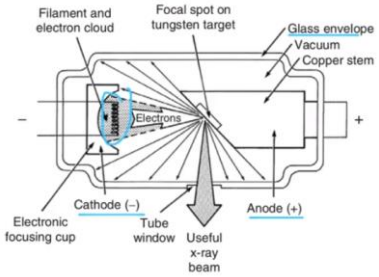
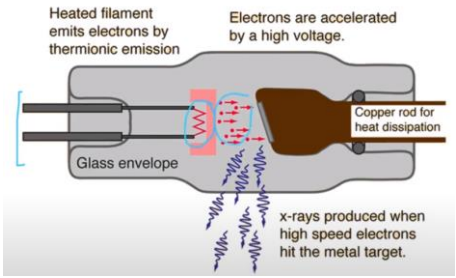
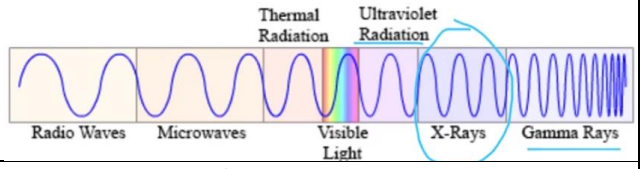
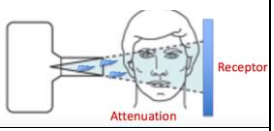
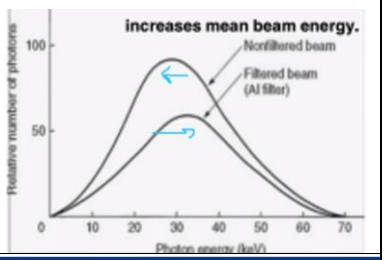
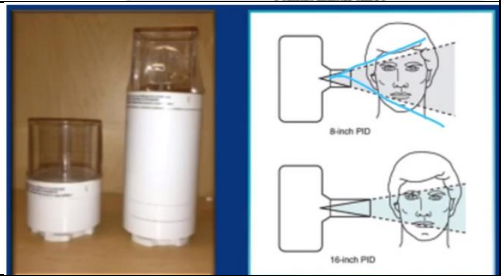
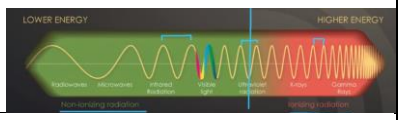
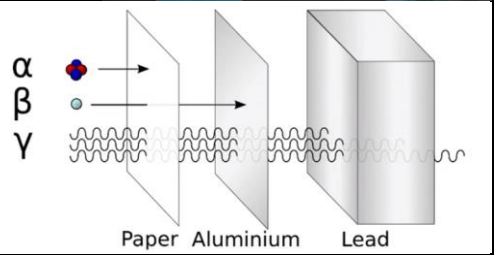
Mental Dental - Oral Radiology

Fundamentals of X-Rays

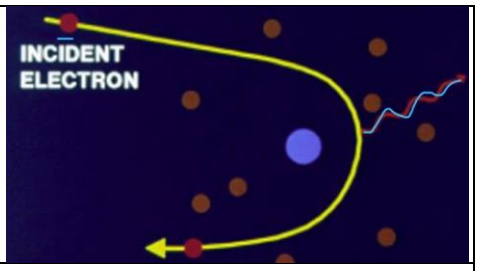
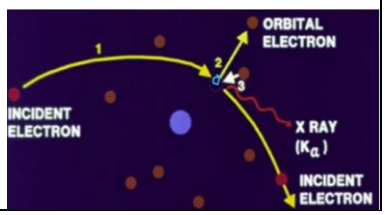
Position-Indicating Device (PID)	Allow you to line up the tube head and distance from the patient 
Within the Tube Head	A circuit heats up a filament -> Emits electrons from the **Cathode to the Anode** Electrons fire towards a Tungsten target -> X-Ray is produced when e^- hits the atoms *Copper rod is present to dissipate the heat  
What is an X-Ray?	High Energy and High Frequency waves - Between UV rays and Gamma Rays on the spectrum 
Attenuation	= How the X-Ray beam weakens as it passes through matter on its way to the receptor - Density of the material it is passes through AND the energy of the photon (kVp) determines how many photons will actually make it to the receptor 
Filtration	= **Involves Aluminum** - Removes the lower energy photos from the bean to ↓ patient exposure (and ↑ image quality) - Conceptually similar to beam hardening 
Collimation	= **Involves Lead** - ↓ Scatter radiation by ↓ diameter of the beam - Rectangular is the **best method to ↓ patient exposure** and also ↑ image quality (by ↓ scatter radiation) 

Cathode (-)	Tungsten filament that produces electrons - Molybdenum focusing cup focuses the beam onto a small focal spot
Anode (+)	Tungsten target converts electrons to X-ray photons - Copper stem dissipates heat
Glass	Insulation
Aluminum	Filtration
Lead	Collimation

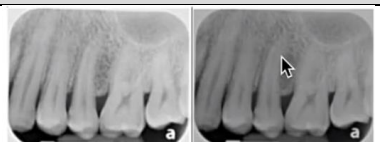
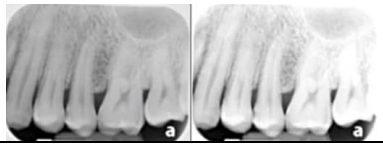
2 Types of Ionizing Radiation

Electromagnetic	= Movement of energy as a combination of electrical and magnetic fields - Shorter Wavelength = ↑ Energy Gamma > X-Ray > UV > Violet-Red > Infrared > Microwave > Radio 
Particulate	= Atomic nuclei or subatomic particles moving at high velocity - **Alpha (α)** or **Beta (β)** particles from Radioactive decay - α is stopped by paper (pussy) - β is stopped by aluminum (this is why we use filtration) 

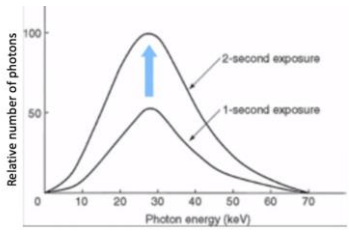
2 Types of X-Ray Production

Bremsstrahlung	= 1º source of X-Ray photons - Electron strikes a target and brakes -> Gives off energy - Generates a **continuous spectrum** of energy 
Characteristic	= 2º source of x-ray photos - Electron accidentally knocks into another electron and drops into a lower energy orbital - Emits a photon of **specific** energy when it moves orbitals 

X-Ray Settings

Definitions	
Inten*sity*	= Quantity of electrons and photons *Effects*: Den***sity*** - Darkness of the image 
Energy	= Quality of electrons and Energy of photos *Effects*: Contrast - Difference among gray values 

Variables

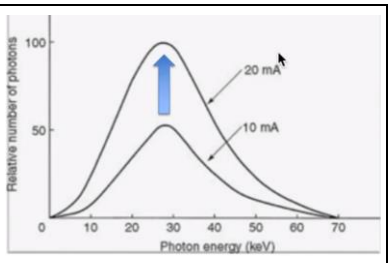
Exposure Time (s)	= Length of time that high voltage is applied to the X-Ray tube and the time that the current flows and produces X-Rays - Changes the ***NUMBER*** of photons - The most frequently altered setting **If**: Too long -> Too dark, overexposed Too short -> noisy and light, underexposed **Affects**: - Intensity (Density) 

Tube Current (mA)

= Flow of e^- from filament to the anode and back to the filament
- Not really adjustable easily

If:
- Too much -> Too dark, underexposed
- Too little -> Noisy, underexposed

Affects:
- Intensity (Density)

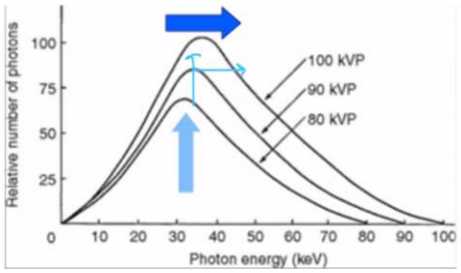


Tube Potential (kVp)

= acceleration of e^- from cathode to anode
- Affects both the number and energy of the photons

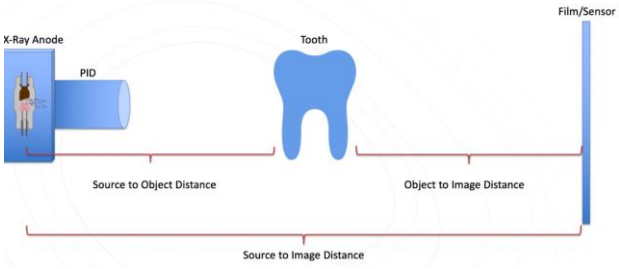
If:
- Too high -> Too gray (not enough contrast), mostly Compton Scattering
- Too Low -> Too light (very high contrast), Mostly photoelectric absorption

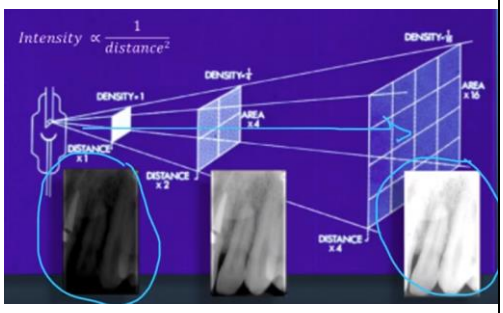
Affects:
- Density and Intensity



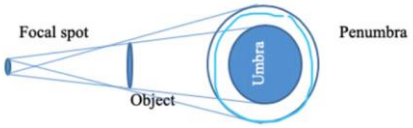
Distance
- ***Inverse Square Law = Further from the source, ↓ photons per unit area***
  - ***Intensity is inversely proportional to the distance (short distance = ↑ intensity = ↑ Density = Dark)***

Operator should be at least 6ft away





Ideal = ↑ Source Object distance and ↓ Object-Image Distance
- ↑ SOD = ↓ intensity (density), ↑ Quality
- ↓ OID = ↑ Quality, ↓ Magnification

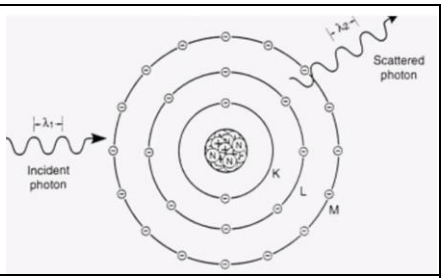
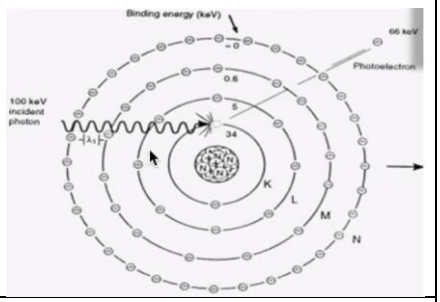
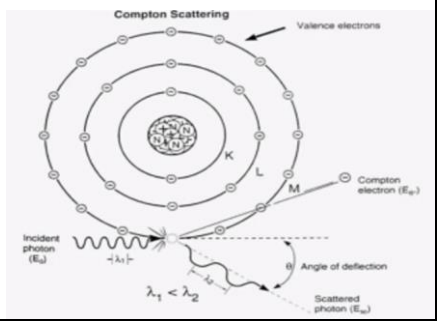


Geometry
- Umbra = Shadow behind an image
- Penumbra = Side Shadow (blurriness)
  - *Size depends on*: Focal Spot Size, Source-to-Object distance, Object to image distance
  - ***Ideal***: ↓ FSS, ↓ OID, and ↑ SOD = Chris P image

Everything in one Table ->

	Intensity	Energy
↑ seconds	↑ density	
↑ mA	↑ density	
↑ kVp	↑ density	↓ contrast
↑ filter	↓ density	↑ contrast
↑ distance	↓ density	

Radiation Dose

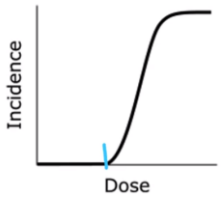
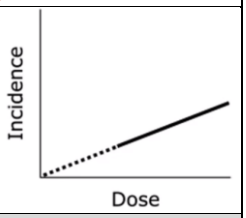
Coherent Scattering	= Incident photon contacts an **outer** electron - No energy loss, just a change in direction - Only about 8% of interactions (pretty minor) ***Effect***: - ↓ Contrast 
Photoelectric Absorption	= Incident photo *contacts* and *ejects* an **inner** electron and forms an **ion pair** - If your kVp is too ↓ ↓ you will get ↑ Photoelectric Absorption - About 30% of interactions ***Effect***: - ↑ Contrast 
Compton Scattering	= Incident photon contacts an **outer** electron and form and **ion pair** - If kVp is ↑ ↑ you get ↑ Compton Scattering - About 62% of interactions in a dental X-ray beam ***Effects***: - ↓ Contrast 

Dosimetry

Term	Unit of Measure	What It Is
Exposure	Roentgen 1 C/kg = 3.88 x 10^3 R	Energy produced by x-ray tube
Absorbed Dose	Gray 1 Gray = 100 rads	Energy absorbed in tissue
Equivalent Dose	Sievert 1 Sievert= 100 rems	Energy absorbed in tissue multiplied by radiation weighting factor
Effective Dose	Sievert 1 Sievert= 100 rems	Energy absorbed in tissue multiplied by tissue weighting factor

➔ Different tissues are affected differently (↑/↓)

Effects

Deterministic	= Hair loss, Cataracts, Skin Damage, Oral Mucositis Threshold Dose needs to be reached -> ↓ than this dose = no effects - 0.1Gy = In-utero birth defects - 0.5 Gy = Cataracts - 3.0 Gy = Radiation burns ***Dental X-Rays are Micro Grays, so they are FAR FAR away from causing Deterministic Effects*** 
Stochastic Effects	= Cancer, Leukemia, Heritable Effects - Accumulates over years of doses. This is why we are conservative Linear, no-threshold model. Dose builds up over years - 0.1Gy -> Anything below this, we can only **assume** the effects are dependent on dose (Extrapolating) - 0.0017% risk ↑ by 1Gy 
Radiation Chemistry	
Direct	= Direct alteration of biologic molecules (Proteins, DNA etc) - Accounts for 1/3 of biologic effects - Effects caused by **α and β particles**
Indirect	= Ionizing radiation converts H_2O into **free radicals** which then alter biologic molecules (proteins, DNA etc) - Account for 2/3 of biologic effects ***Cells that are mitotically active are more radiosensitive*** - ***Most Sensitive***: Hematopoietic Cells, Epithelial Cells, Sperm Cells - ***Least Sensitive***: Nerve cells, Muscle cells

Dose Reduction

- Occupational Exposure limit = 50mSv per year
- ALARA = As Low As Reasonably Achievable
- ALADA = As Low As Diagnostically Acceptable
- Use E/F speed films, or digital imaging
- >18cm source to object distance to ↓ exposure and ↑ clarity
- Rectangular Collimation

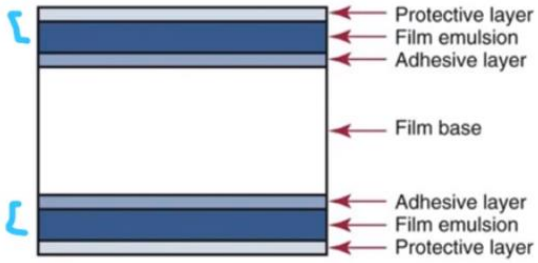
Sources of Radiation Exposure

- Background radiation (just surviving on earth) = 3.1mSc per year -> mostly from Radon
- Man-made radiation = 3.1mSv per year-> Mostly medical imaging, building materials, etc
- Average Annual exposure = 6.2 mSv

**Dental X-Rays are MICRO Sv…SOOOOOO much ↓ ↓ ↓ than what we are exposed to on a daily basis

Technique	Effective dose in µSv	Dose as multiple of average † panoramic dose	Dose per capital background	Probability of x in a million fatal cancer‡
FMX with PSP or F Speed film w Rectangular Collimation	35	2.2	4.3	2
FMX with PSP or F Speed film w Round Cone	171	10.7	21	9
FMX with D Speed film w round cone¶	388	24.1	47	21
Panoramic – CCD†	16.1	1.0	2	0.9
Lateral Cephalometric - PSP	5.6	0.3	0.7	0.3
CB Mercuray- "Panoramic" FOV	560	35	68	30.8
Galileos – (default exposure)	70	4.3	9	3.9
Somaton 64 MDCT	860	53.4	105	47.3

Film vs Digital Imaging

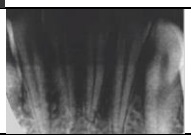
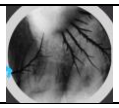
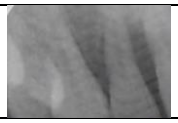
Film	Digital
- Requires Chemicals to process - Requires time to develop - Superior image quality - More radiation dose to the patient **Composition**: - *Base* = Flexible Plastic - *Emulsion* = Silver halide crystals in gelatin material (sensitive to light) -> this is where the magic happens - *Intensifying Screens* = Coated w/ fluorescent phosphor to ↓ amount of exposure needed (converts photon energy to light), but also ↓ resolution  **Speed**: - A < B < C < **D** < E < **F** - *Determined by several factors:* - Larger crystals = faster films - Double emulsion = Faster film - Radiosensitive dyes in emulsion = Faster film **Imaging**: - X-Ray photos chemically change the silver halide crystals into neutral silver atoms in the emulsion -> Creates latent image **Chemical Processing** 1. Developing 2. Fixing - Wash away unexposed silver halide crystals 3. Washing - Wash away residual chemicals 4. Drying	- No chemicals needed - Instant viewing - Image enhancement w/ computer software - ↓ Radiation Dose to patient **Ex**: - PSP - CCD/CMOS **PSP**: - Barium Fluorohalide plates capture and store X-ray energy from dental exposure - Need scanner to scan the image into the computer **CCD/CMOS:** - Silicon sensor chip captures x-ray and rapidly displays image on the monitor

Chemical Processing	
Developing	= Converts exposed crystals into metallic silver grains that appear dark on the radiograph - **Phenidone** = 1st e- donor that reduces silver ions to metallic silver at latent image site - **Hydroquinone** = Provides electron to reduce the oxidized phenidone back to its original active state (so it can continue to work) If final image is light: Developer is probably old 
Fixing	= Wash away unexposed silver halide crystals - **Ammonium Thiosulphate** = Cleaning agent, removes undeveloped silver halide crystals - **Aluminum Salts** = Tanning agent, hardens and preserves the emulsion - **Acetic Acid** = Acidifier, maintains the fixer's level of acidity and neutralizes the developer - **Sodium Sulfite** = Preservative, Prolongs shelf life of the solution - **Water** = Solvent, Dissolves the other ingredients
Washing	= Wash away residual chemicals
Drying	

Detector Characteristics

Contrast Resolution	= Ability to distinguish shades of Gray Film > Digital
Spatial Resolution	= Ability to distinguish 2 close points Film > CCD/CMOS > PSP
Detector Latitude	= Exposure range providing useful image PSP > CCD/CMOS > Film
Detector Sensitivity	= Dose required to achieve standard gray level CCD/CMOS is ½ the speed of n F Speed Film -> WAY less radiation

Troubleshooting

Underexposed Image	- Inadequate Exposure Time - Inadequate Development Time - Old Development Solution - Temp too low 
Overexposed Image	- Exposed for too long - Exposed to light 
Creases	
Static Electricity	
Film is placed backwards	= Herringbone/Tire Track  Effect

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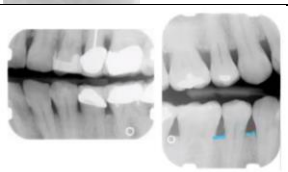
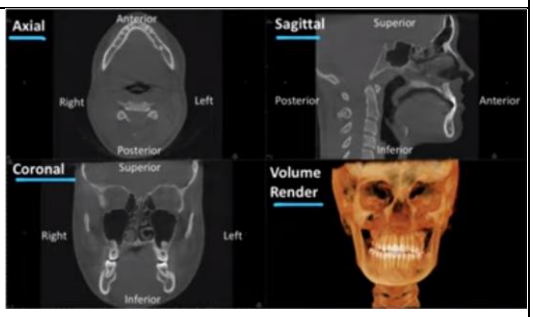
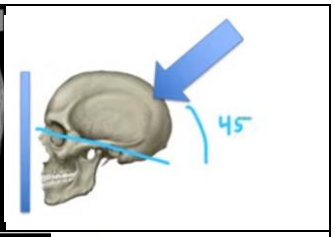
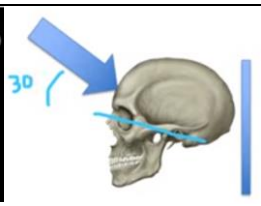
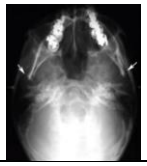
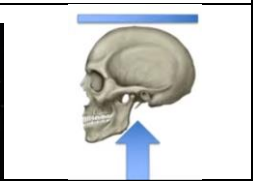
Types of Radiographs

Intraoral/Direct	Extraoral/Indirect
- Periapical (PA) - Bitewing (BW) - Occlusal	- Panoramic (Pan - Cephalometric (Ceph) - Cone Beam Computed Tomography (CBCT)

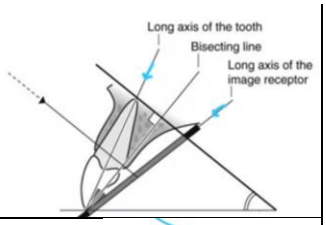
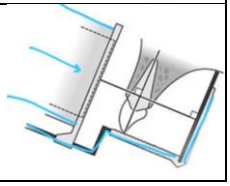
Intraoral	
Periapical	= Used to capture the roots and apices of teeth - Manifestations of pulpal or periodontal disease = Used also to capture anterior interproximal decay 
Bitewing	*Does not usually show root apices = Used for posterior interproximal caries detection and bone levels - Angulation is more parallel for BW's so bone is more accurate 
Occlusal	Receptor lies flat on the occlusal plane - Captures from Canine to Canine = Used for further assessments of: Trauma, Impacted Teeth, Supernumerary 

Extraoral	
Panoramic	Useful for screening, pathology, and 3rd molar location
Cephalometric	***Lateral*** - Relationship of teeth and jaws in relation to the cranium - Treatment changes - Growth ***Posterior-Anterior (PA)*** - Transverse Asymmetry - Not really used anymore, mostly CBCT now 
Cone Beam Computed Tomography (CBCT)	***3D radiographic image:*** - Axial View (top bottom) - Sagittal (Side-side view) - Coronal (Front Back view) - 3D Volumetric render *Used for:* - Implant Planning - Endodontics (strange anatomy) - Orthodontics - TMJ (Hard tissue only) -> MRI is used for soft tissue - Pathology 

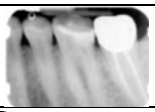
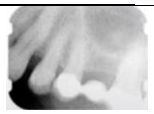
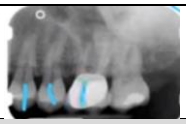
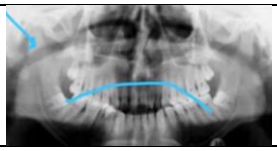
Specialized Views

Waters View	PA Ceph at an angle (45° to the orbito medial line) *Best for:* - Paranasal Sinus - Midface - Orbits  
Towne's View	PA Ceph at an angle again (30° from the orbito-medial line) - Angled directly at the condyles. Eliminates the superimposition of the Mastoid and Zygoma over the condyles *Best for:* - Condyle  
Submentovertex View	Base projection of the skull *Best for:* - Basilar skull fractures - Zygomatic fractures  

Techniques

Bisecting Angle Technique	= Central ray of the X-Ray beam is aimed perpendicular to the imaginary bisecting line between the long axis of the tooth and the long axis of the receptor - This creates 2 equal triangles…which means there is minimal magnification! 
Paralleling Technique	= Receptor is placed parallel to the long axis of the tooth - Central ray of the x-ray beam is aimed perpendicular to the long axis of both the tooth and receptor *Less distortion and ↑ quality image* - Problem is that the Object film distance is ↑ (less comfy and more magnification) 

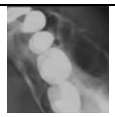
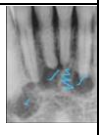
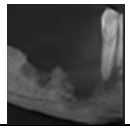
Common Errors

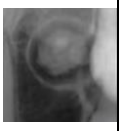
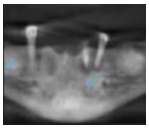
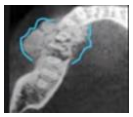
Elongation	= Most common error - Could be anglulation issue or bending of the film 
Cone Cut	x-Ray beam and receptor were not lined up properly 
Underexposed	Grainy or too light image - Exposure time is too short - ↓ mA - ↓ kVP 
Overexposed	Image too dark - ↑ mA - ↑ kVp 
Double Exposure	2 Images exposed on the same PSP plate 
Pans	
Motion	Wavy and Irregular borders - If patient swallows or moves 
Chin Down	= Big Smile 
Chin Up	= Frown
Ghosting	RO Artipfct is projected to the other side of the image 

Radiograph Interpretation

- Know what normal is
- Compare R and L sides (especially with Pan)
- Categorize the disease or abnormality
- Start globally -> then go locally

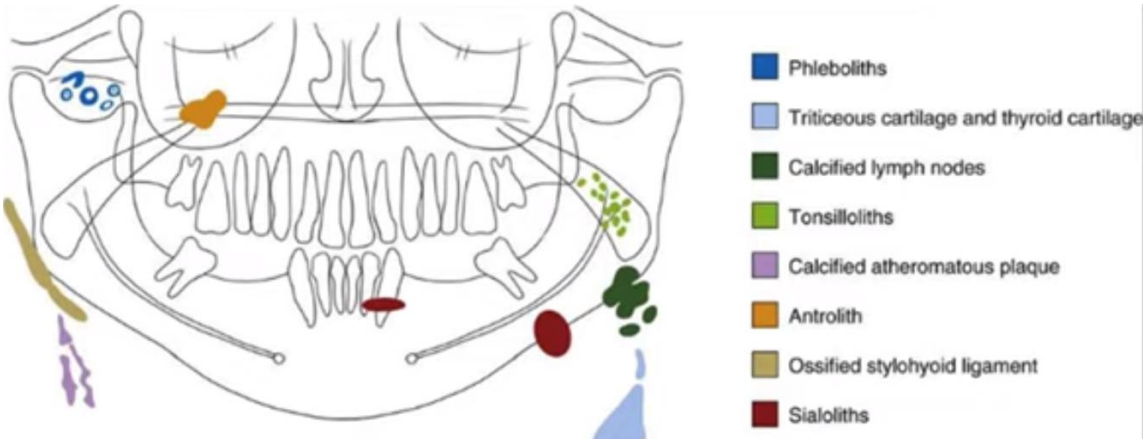
Descriptions

Radiolucent Descriptors			
Corticated Unilocular 	One Compartment Radiopaque Border 	**Non-Corticated Unilocular** 	One Compartment No clear border Diffuse edges 
Multilocular 	Multiple compartments separated by thin septae 	**Multifocal Confluent**	Multiple points of origin converging onto each other 
Moth-Eaten	Irregular, ragged edges Can be generalized or localized 		

Radiopaque Descriptors			
Focal Opacity 	Single Site Homogenous = Same density Heterogenous = Varying density 	**Target Lesion** 	Radiopaque Center RL Band around the RO center Corticated border around the RL halo 
Multifocal Confluent 	Multiple Points of origin converging on each other 	**Irregular** 	Ill defined Edges 
Ground Glass 	Fine granular/orange peel appearance 	**Mixed Density** 	Both RO and RL May or may not be corticated 
Soft Tissue Opacity 	Calcification embedded within the soft tissue 		

Soft Tissue RO in a Pan

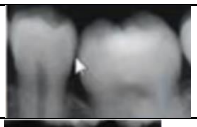
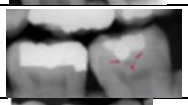
Benign vs Malignant Lesions



	Benign		Malignant
Margins	Well-defined (narrow zone of transition), smooth, regular, corticated		Ill-defined (wide zone of transition), ragged, moth-eaten
Shape	Round, oval		Irregular
Internal Architecture	**Tumors** Multilocular, more likely to resorb roots	**Cysts** Unilocular, hydrostatic, tend to be more corticated	Usually radiolucent
Location	Coronal or above mandibular canal		Ramus or posterior body of mandible
Effect on Cortical Bone	Expansion, thinning, displacement, may erode if aggressive		Erosion, destruction
Effect on Maxillary Sinus	Displacement		Erosion, destruction
Effect on Mandibular Canal	Displacement, no neurosensory defects		Invasion and destruction, anesthesia or paresthesia
Effect on Tooth Position	Displaced teeth, may prevent eruption		Floating teeth
Effect on Tooth Roots	Horizontal resorption		Vertical resorption resulting in spiked roots, or no resorption at all (floating teeth)
Effect on PDL Space and Lamina Dura	N/A		Asymmetric widening of PDL space and loss of lamina dura

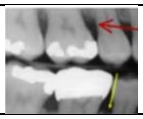
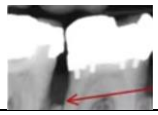
Caries Detection

Tooth needs 30-40% demineralization before it will appear on a radiograph

Interproximal	Small triangle at or below the contact point	
Occlusal	Subtle RL beneath the fissure - Hard to trace	
Buccal	Small circle in the buccal or lingual pit	
Recurrent	Gingival to the restoration	
Root	Hemispherical at or below the CEJ - Important to distinguish from cervical burnout	

Periodontitis Detection

- Use BW Radiographs, the Bone levels are more accurate -> Except for Anteriors were we can't really use BW's
- Alveolar crest is fuzzy =
- Normal bone levels: 1-2mm apical to the CEJ

Mild Bone Loss	Upper 3rd of root	
Moderate BL	Middle 3rd of root	
Severe BL	Lower 3rd of root