Radiology

Lec. 3 Factors relating to the production of radiograph د. اريج

Radiation Quantity: is the number of x-ray photons in the useful beam. The factors affecting x-ray quantity are :

1. mAs: x-ray quantity is directly proportional to milliamper-seconds.
2. kVp: x-ray quantity is directly proportional to the square of kilovolt Peak.
3. Distance: x-ray quantity varies inversely with distance.
4. Filtration: x-ray quantity is reduced by filtration, which absorb the low- energy photon of the beam.

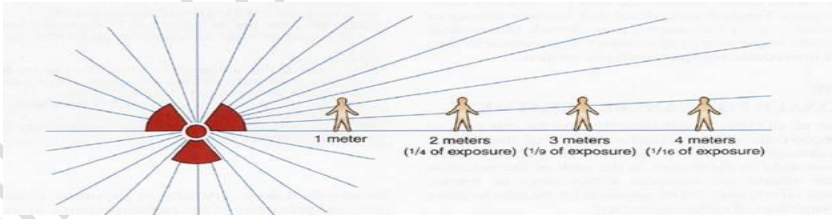
Radiation Quality: is the penetrating power of the x-ray beam, which is quantified by HVL.
The factors affecting x-ray quality are:

1. kVp: x-ray penetrability is increased as kVp is increased.
2. Filtration: x-ray penetrability is increased when filters added to the beam.

- **Inverse square law**:- the low stated that ((the intensity of radiation inversely proportional with the square of distance measured from the source of radiation to the point of measuring the radiation intensity.

I: intensity $I \times \frac{(D_2)^2}{(D_1)^2}$

D: Distance



Factors relating to the production of radiograph

A/ Factors related to the radiation beam.

B/ Factors related to the object.

C/ Factors related to the X- ray film.

A/ Factors related to the radiation beam.

1. Exposure time: It's the interval during which X- rays are being produced. exposure time is directly related to the total photon production thus increase exposure time cause increase in the quantity of X- radiation that's why exposure time has direct effect on film density.

2. Milliamperage: Its related to amount of electricity pass through the filament circuit. So it's directly control the rates of X- ray photon production thus it has direct effect on film density.

3. Kilovoltage: kV it refers to the potential difference between cathode and anode in the x- ray tube the higher kVp the greater is the potential difference and the greater is the energy of X- ray photons.

4. Tube – film distance: this distance consist of (tube – object distance) and (object – film distance)
   - The tube – film distance affect the intensity of radiation (according to inverse square law
   - The tube – film distance affect the exposure time directly.
   - The distance proportion inversely with the intensity of radiation.
   - The distance affect the dose of radiation because decrease the tube – film distance make the X- ray beam more diverge behind the skin area and more tissue is irradiated. While increase the distance makes the beam less diverges and reduces the amount of tissue irradiated.

5. Focal spot size: the focal spot or called the source of radiation must be as small as possible to get best image quality. So any movement in the head of X- ray machine affect the focal spot size.

6. Collimation: collimator used to control the size and shape of the beam.

Effect of collimation:

- Reduce the amount of tissue irradiated
- Minimize the production of secondary radiation fog.

* Fog: - is the unwanted film density (blackening) and thus reduce radiographic contrast.

7. Filtration: the effect of filtration is the absorption of long wave length X- ray photons that have low penetrating power (can't penetrate the hard calcified tissue). The result of filtration of X- ray beam is hardened beam (more short wave-length photon with high penetration power) so increase the half – value layer, also increase filtration affect the contrast and density but in different way, the contrast is decreased (long scale) like the effect of increase kV. While the density is decreased because when filtration increase the result is the absorption of not only long wave length photons but even some of short wave length photons so the number of X- ray photons or the quantity of radiation is reduced so the density is reduced.

8. Equipment efficiency: dental X- ray machine differ in construction and efficiency so the quality and quantity of X- ray beam vary from machine to another.

B – Factors relating to the object:

The object is basically an absorbing X- ray medium, so 2 points important about the object during exposure to X- ray:

1. Thickness of the object: Thick object required more radiation to make a radiographic image so it's often advisable to increase kV or mA and /or exposure time in order to increase the amount of X- ray photons.

2. Density of the object: density refers to weight per unit volume of the object . In dental radiography enamel of the tooth has highest density of all body tissues. increase the density of the object increase its ability to absorb X- radiation. So hard tissue like enamel absorb great amount of radiation when compared with absorption of soft tissue like pulp because of object density.

C – Factors relating to the X- ray film:

1. **Reduction of secondary radiation:**

Secondary radiation include scattered, stray leakage or any other radiation that not belong to primary X- ray . Secondary radiation is un desirable because it reaches all parts of the film and produces film fog. Several ways to minimizing this radiation like:-

- Using as small beam of radiation as possible.
- Proper collimation.
- In intra oral film a sheet of lead foil is placed behind the film in the film packet.
- In extra oral film a grid is placed between the object and the film. The grid is an extremely effective device for reducing the amount of scattered radiation that exiting an object and reaching the film. Its composed of alternating strips of a radiopaque material (usually lead) and strips of radiolucent material (often plastic). so the grid transmit only those x-rays whose direction is on straight line from the source to the film (image receptor) and absorb the remnant scattered radiation.

2. **Film and film storage:**

X- ray film must stored in light - tight containers because the Ag Br Crystals in the emulsion are sensitive to light as well as to X- ray. Also film must stored in lead - lined box to keep the films away from the stray radiation, also stored in place away from excessive temperature or humidity and we should used it before the expiration.

3. Intensifying screen:

is a device that convert the energy of x-ray beam into visible light, which interact with x-ray film and forming the latent image. Intensifying screen used in extra oral film to reduce patient dose by converting the x-ray to light so one x-ray photon give rise to many light photons, the number of x-rays required to produce the same density on the film is markedly reduced.

4. Film processing:

The latent image is formed when silver halide grains are exposed to x-ray, then only the exposed grain will form the visible image by development. while the unexposed grains removed from emulsion by fixing and make a permanent image.

As mentioned in previous lecture, its either automatic or manual steps, the automatic processing is preferred because it faster and resulted in better image quality.

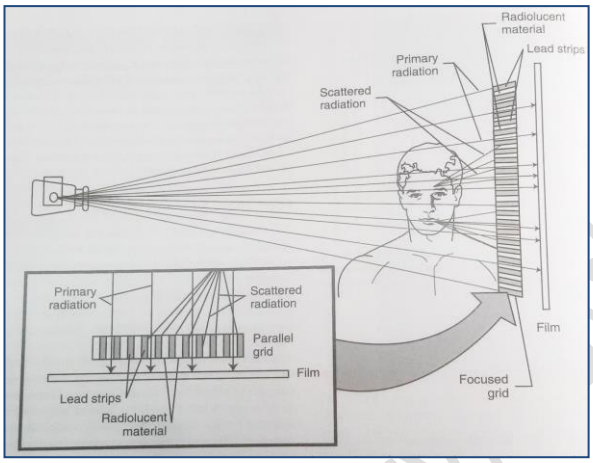


Fig. 1: extra oral grid demonstrating the lead strips and the scattered radiation elimination.

Ideal radiographic projection

The term image quality describes the subjective judgment by the clinician of the overall appearance of a radiograph. It depends on density, contrast, latitude, sharpness, resolution and other factors. Ideal radiograph demonstrates certain image qualities include:

A – Radiographic image that is sharp.

B – Radiographic image that is shaped like the object.

C – Radiographic image that is the same size as the object.

- **Sharpness:** is the ability of a radiograph to define an edge precisely (e.g. the dentino-enamel junction, a thin trabecular plate) , or measures how well a boundary between two areas of different radio density is revealed.
- **Image Size Distortion (magnification)** is the increase in size of the image on the radiograph compared with the actual size of the object**.**
- **Image shape distortion** is the result of unequal magnification of different parts of the same object (Is the change in the shape of image as compared to the object due to improper alignment of the tube ,film or the object).
- **Penumbra:** Is the amount of un sharpness of the image so penumbra is the area of partial shadow.

❖ **Umbra:** Is the area of total shadow and its exist only when the object absorb all of X – rays.

Penumbra is created by the size of focal spot (source of radiation), the larger the spot size the greater is the penumbra (the amount of un sharpness). penumbra not only affected by focal spot size but also affected by tube – object distance and object – film distance so the closer tube – object distance the greater is the penumbra while the closer object – film distance the lesser is the size of penumbra.

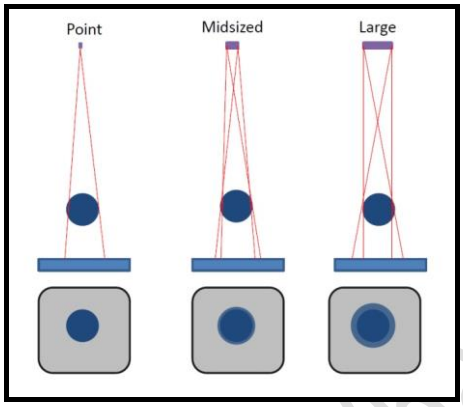


Fig. 2: effect of focal spot size on penumbra and umbra

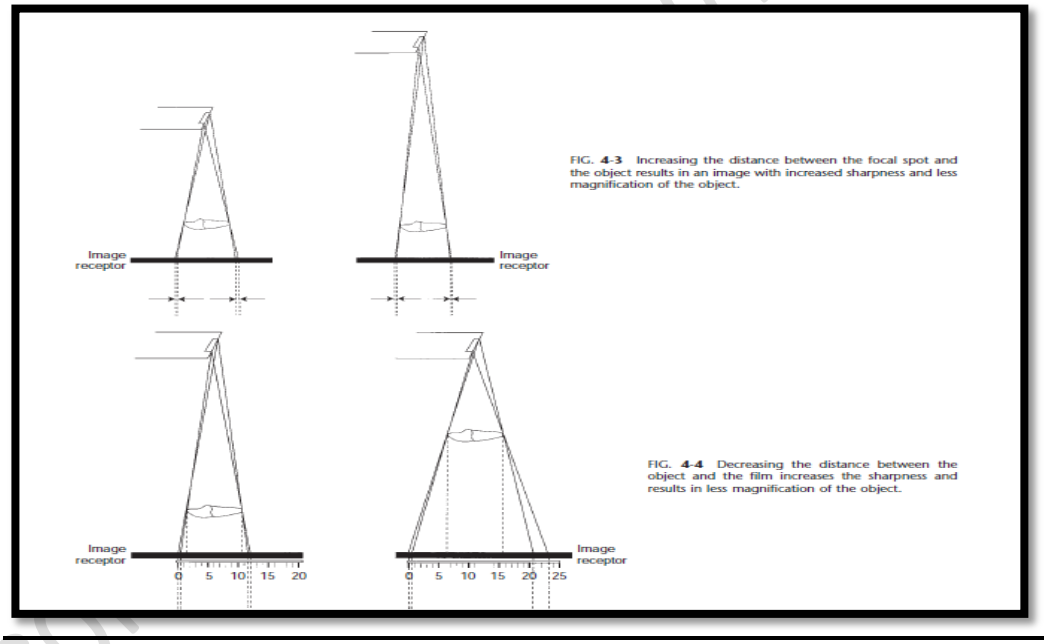


Fig. 2: effect of tube-object distance and object –film distance on umbra and penumbra.

Basic Principles of Projection Geometry for Radiography

1. Source of radiation should as small as possible.
2. Tube – object distance should be as great as possible.
3. Object – film distance should be as small as possible.
4. Film should be parallel to an easily identifiable plane of the object.
5. Central ray of the beam should be perpendicular to the film.

The first 3 principles deal with the image sharpness while the last 2 principles required during exposure as a technique.

Radiographic errors and Artifacts:

Classified into three categories:

A. **Technique and projection errors**
B. **Exposure errors**
C. **Processing errors**

1. **Cone cut**: is clear unexposed area result from positioning fault when the X- ray beam not completely cover the film during exposure.
2. **Back side exposure**: when the film placed in wrong position making the non-exposure side facing the beam, the result is the image with the pattern of the lead foil is evident.
3. **Double exposure**: when same film used and exposed twice to X- ray this result in excessive dense and blurred image .
4. **Elongated image**: vertical angulation of X- ray tube was too shallow.
5. **Shortened image**: vertical angulation was too steep.
6. **Over lapping of adjacent structures**: when horizontal angulation was incorrect.

Horizontal and vertical angulations

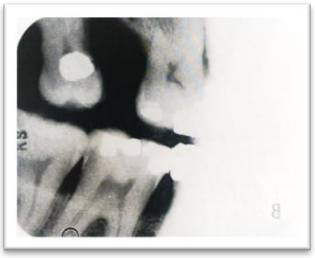
- Horizontal angulation: refers to X-ray beams direction in a horizontal plane.
- Vertical angulation: refers to X-ray beam direction in a vertical plane.

Plus vertical angulation: when the beam is tipped down ward

Minus vertical angulation: when the beam is tipped upward.

7. **Blurred film**: due to excessive bending of the film during placement for exposure.
8. **Fingernail marks**: resulting black lines when pressure by fingernail as an example put on the film or sometime we have (**finger print impression**) in the emulsion.
9. **Pale X- ray film**: this due to either under exposure, or under developing.
10. **Dark X- ray film**: this is due to either over exposure or over development .
11. **Completely clear film**: when put the film in fixer before developer. or when the film didn't receive radiation
12. **Reticulation**: it mean crack of emulsion when subjected to great change in temperature between different processing solutions. Note: temperature must go from warm to cold.
13. **Wet and leaking packets**: when we have black borders due to light entering a poorly sealed film wrapper.
14. **Undeveloped area**: this appear as clear area caused by incomplete immersion of the film in developer (sometimes called developer cut-off) or sticking the film in the developer to the side of the tank.
15. **Scratched film**: when the film is processed in manual processor, the soft emulsion is easily scratched due to rough handling of the film , ex. scratched by holder, tank or nails.

16. **Developer spot**: black dots or dark spots on the film caused by drops of developer solution that was accidently spilled on the film before it was developed.
17. **Fixer drop**: white dots or light spots on the film caused by drops of fixer solution that was accidently spilled on the film before it was developed.
18. **Yellow or brown stain**: stain or discoloration of film due to contaminated solution or insufficient rinsing.



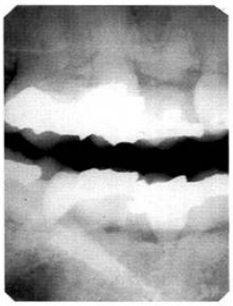
Cone cut

back side exposure

double exposure

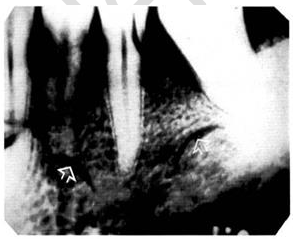
Elongation

shortening



overlapping

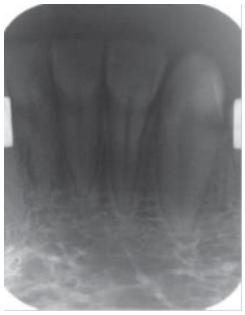
Blurred image



finger nail mark

finger print

Pale film

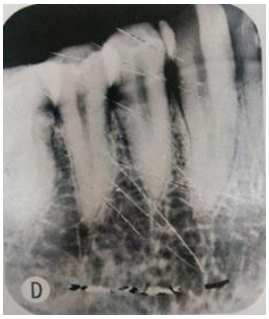


dark film

reticulation

Wet or leaking packet

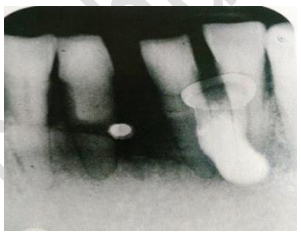
undeveloped area



scratched film

Developer spot (occlusal film)

developer spot

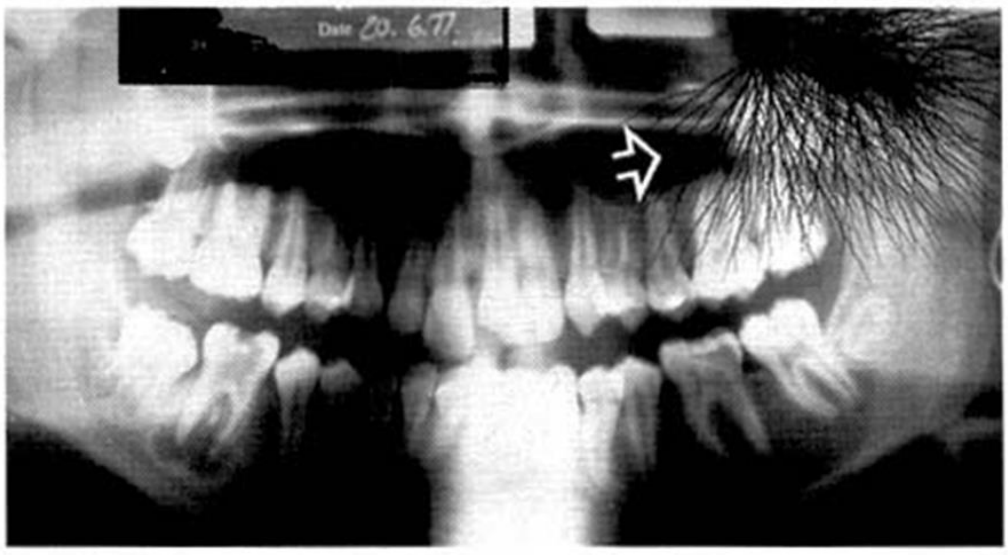


fixer spot

yellow or brown discoloration

discharge of static electricity

complete clear film



Discharge of static electricity seen in panoramic radiograph (OPG)