L.5 # Intraoral Examination Techniques

By

Mahmood Al-Fahdawi B.S., M.Sc., Ph.D.

Oral Radiology Teacher, Anbar University

Intraoral radiographic techniques:

There are three main types of intraoral radiographs:

1. Periapical radiograph
2. Bitewing radiograph
3. Occlusal radiograph

The anatomic area of interest and type of pathology suspected helps the clinician to decide the type of radiograph to be taken.

Periapical Examination:

The Periapical radiograph is the basic investigation that gives graphic information about the alveolar bone, periodontal areas and the hard tissues of the tooth. Each image usually shows 2-4 teeth. It shows the apex of the tooth and surrounding bone as well as the entire crown.

Indications:

1. The clinical indications include:
2. To visualize Periapical region.
3. Detection of apical infection/inflammation.
4. Detailed evaluation of apical cysts and other lesions within alveolar bone.
5. To study crown and root length.
6. Assessment of the periodontal status.
7. To determine the integrity of the lamina dura.
8. Assessment of root morphology.
9. Selection of cases for endodontic treatment.
10. During and after endodontic treatment.
11. In the evaluation of fracture of the teeth and associated alveolar bone.
12. To evaluate root apex formation.
13. To study eruption pattern and stage of eruption.

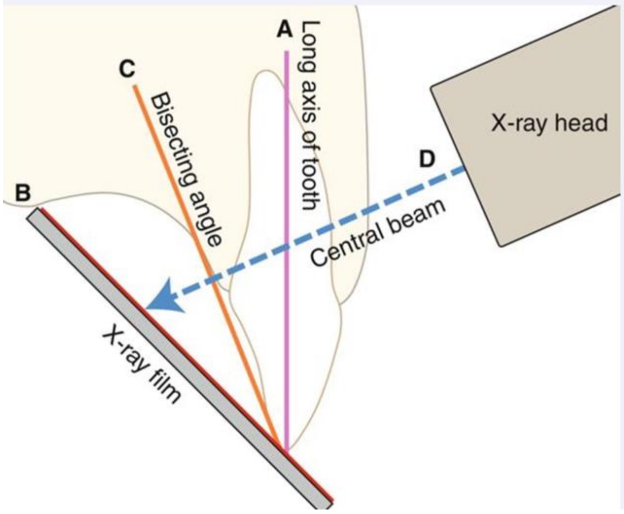
14. Assessment of the presence and position of unerupted or impacted teeth, supernumerary teeth, and root stumps.
15. Post-surgical evaluation of the socket.
16. Preoperative assessment and postoperative appraisal of apical surgery.
17. Evaluation of implants postoperatively.

Radiographic techniques

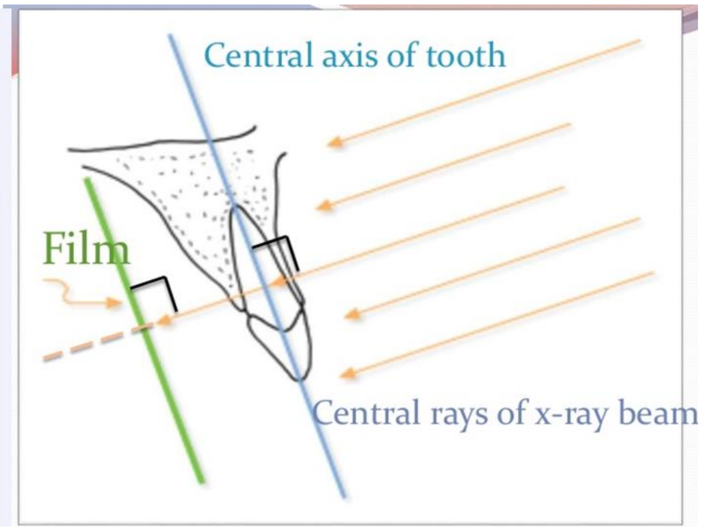
Basically there are two techniques for taking periapical radiography:

- Paralleling technique.
- Bisecting angle technique.

Bisecting Technique



Paralleling Technique

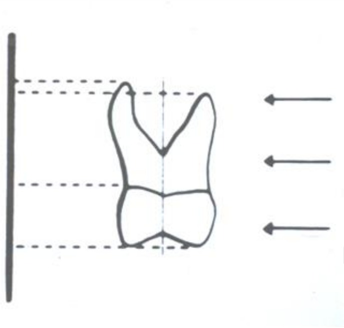


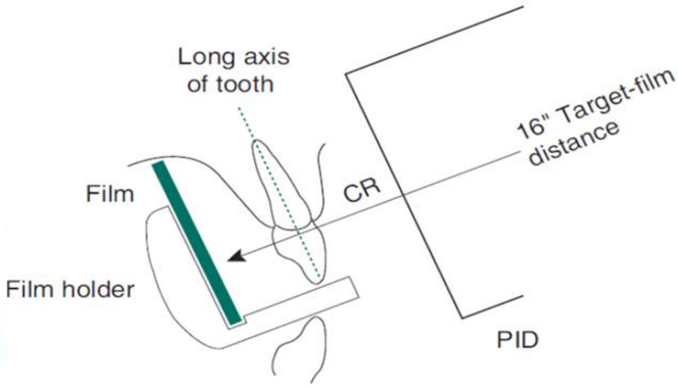
Paralleling Technique:

Extension cone paralleling technique

Right angle technique

Long cone technique

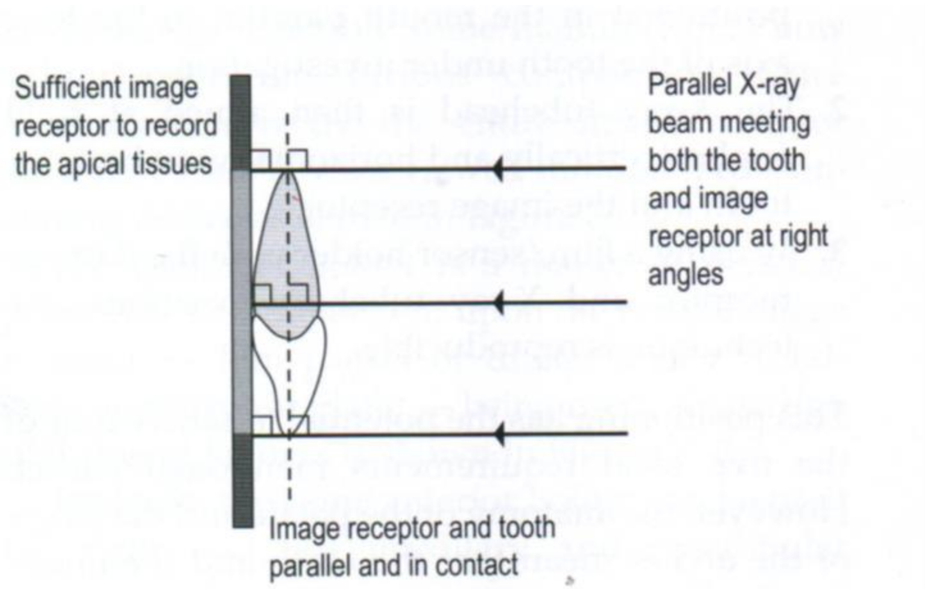




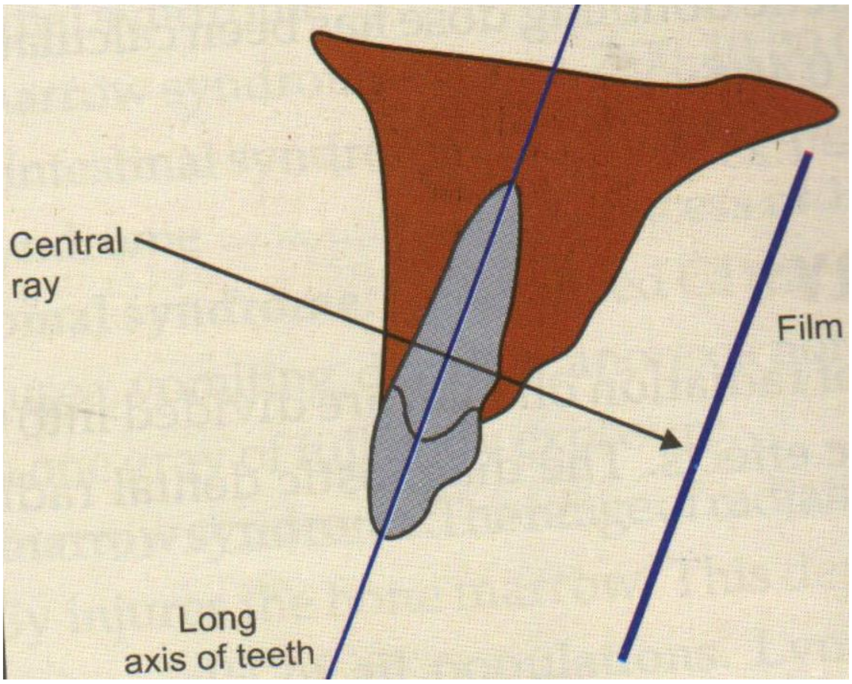
The Paralleling Technique:

Patient Preparation:

1. Infection control procedures.
2. Explain procedure.
3. Seat the patient.
4. Position the patient upright in the chair.
5. Adjust headrest.
6. Place lead apron, thyroid collar.
7. Remove all objects from the mouth.



The ideal geometrical relationship between image receptor, tooth and X-ray beam.



For the tooth and image receptor to be parallel they have to be positioned some distance apart.

The paralleling technique requires:

1. The film be placed parallel to the long axes of the teeth being radiographed.
2. The x-ray beam be directed at right angles to both the film and long axes of the teeth and therefore there is minimum geometric distortion, less magnification and more definition.

When placing a film in a patient's mouth, the radiographer must keep in mind that the long axes of the teeth do not parallel the midsagittal plane. Most maxillary teeth flare out slightly, tipping the root apices toward the center of the palate.

The mandibular anterior teeth often have a similar inclination, with the root apices tipped toward the floor of the mouth. Mandibular premolars are more upright, and the mandibular molar crowns may be lingually inclined, placing the roots in a slightly buccal position. The relative positions of the teeth in the jaws must be kept in mind during film placement.

In order to achieve parallelism between the long axes of the teeth and the film, the film must be placed away from the teeth, toward the midline of the oral cavity. If the film is placed too close to the teeth, parallelism is very difficult to achieve. Additionally, films that are placed too close to the teeth may not record enough tissue in the area of the root apices.

The alveolar process just lingual to the teeth prevent a film from reaching the depth of the palate or floor of the mouth. To ensure adequate coverage and parallel placement, films must be positioned away from the teeth, with the patient biting near the anterior edge of the bite block.

An increased film-to-object distance results in some magnification and geometric unsharpness in an image; the proper placement of the film in the paralleling technique creates such a distance between the film and the objects being imaged. To compensate, a long (16- inch) x-ray source-to-film distance (SFD) is used to help minimize the magnification and unsharpness generated by the distance between the film and the teeth. The paralleling technique is sometimes referred to as the "long-cone" technique because of the length of the position-indicating device (PID) that is required.

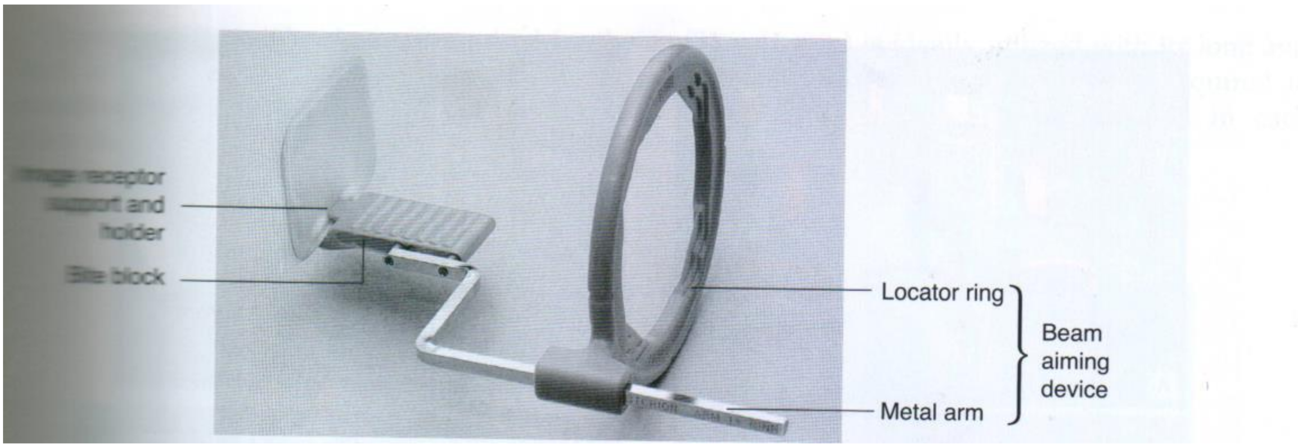
In order for the film to remain parallel to the long axes of the teeth, a film holder must be used; the patient cannot hold the film and keep it in its proper position. There are many types of film holders available commercially. Several have some sort of an indicator in addition to the film holder to help with beam alignment. Proper infection control dictates that film holders should be autoclavable or disposable.

A variety of holders has been developed for this technique could be Rinn XCP instrument (X-extended, C-cone, and P-paralleling). The three basic components:

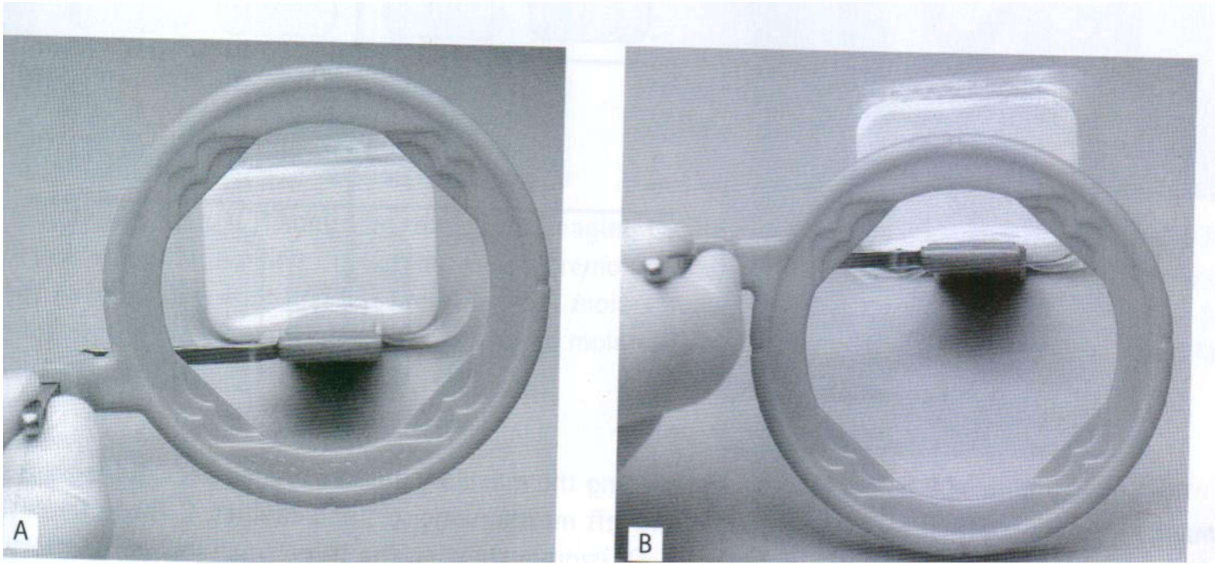
- A mechanism for holding the image receptor parallel to the teeth that also prevents bending of the receptor.
- A bit block or platform.
- An X-ray beam aiming device.

The holder design used depends upon whether the tooth under investigation is:

1. Anterior or posterior.
2. In the mandible or maxilla.
3. On the right or left hand side of the jaw.



Posterior Rinn XCP image receptor holder.



A. The appearance of the film packet when viewed through the locator ring of a correctly assembled Rinn XCP holder B. The appearance when the film holder has been assembled incorrectly.

X-Ray Beam Alignment:

The x-ray beam must be aligned so that it is perpendicular to the film and long axes of the teeth in both the vertical and horizontal planes. The vertical angulation of the beam can be adjusted by pointing the PID up or down. Vertical angles are usually indicated on a scale along the sides of the tubehead. Positive angles are formed when the PID points down, and negative angles are formed when it points up.

The horizontal angulation of the x-ray beam is adjusted by directing the PID to the left or right in the horizontal plane. This angulation is not marked on the tubehead. The film should be placed so that the x-ray beam passes through the interproximal contacts of the teeth and is perpendicular to the film and long axes of the teeth. If the beam is misdirected in the horizontal plane, the proximal aspect of one tooth will be projected over the proximal aspect of another, creating an overlapped contact. Correct horizontal angulation allows clear visualization of the interproximal areas; these contacts are said to be open.

The beam should be centered on the film packet so that the entire film is exposed to the radiation. A misaligned beam that covers only a portion of the film results in a partial image on the film. The portion of the film that is unexposed will have no image, and the unexposed area is often called a "cone cut".

As was previously mentioned, many commercial film-holding devices have beam alignment indicators attached to them, making the task of beam alignment easier. However, these devices are not foolproof. Care must still be taken to ensure that the beam is perpendicular to the film and teeth. Some film holders collimate a circular beam to a rectangle only slightly larger than the film. Particular care must be taken so that the beam is aligned perpendicular to the film in both the vertical and horizontal planes, so that a partial image is avoided. Some x-ray units have rectangular PIDs to reduce patient exposure, and the use of a film holder with an alignment indicator makes proper imaging easier. Because the beam of radiation is only slightly larger than the film in a unit with a rectangular PID, the PID must be carefully aligned with the film to avoid partial images.

Seating the Patient:

The patient should be comfortably seated, in an upright position if possible. The supine position may be used for a few films during an endodontic or surgical procedure. The patient's head and back should be supported. The patient's medical history should be briefly reviewed if it has not been previously addressed by the radiographer. The patient should be asked to take out all removable items from the mouth (including chewing gum), and eyeglasses should be removed. The patient must always be draped with a lead apron and thyroid collar, even if only one exposure is to be made. The oral cavity should be inspected for the presence of any anatomic variations or other abnormalities that might radiographs are positioned in the mouth.

Preparing the Unit:

Exposure factors should be checked and set prior to placing the film in the patient's mouth. It is also advisable to place the tubehead near the area of interest, so that fewer alignment movements are made with the film in the patient's mouth.

General Procedures for Film Placement:

Start by taking any anterior periapical films first. If #1 size films are used, they are smaller and easier for most patients to accommodate. This will enable the patient to grow accustomed to the procedure before the posterior films are placed. The relative ease of the procedure in the anterior will allow you and your patient to tackle the posterior placements with greater confidence.

Films for anterior teeth (cuspids and incisors) are always placed with the long portion of the film in a vertical direction; posterior films (for premolars and molars) are always placed in a horizontal orientation.

The all-white side of the film packet should face the lingual aspect of the teeth. Place the film packet firmly into the film holder so it will not be dislodged during placement.

In the maxilla, remember to keep the film packet away from the teeth, toward the midline of the oral cavity, into the highest portion of the palatal vault. Initially, place the film holder so that a V is formed over the teeth. Then bring the horizontal portion of the film holder into contact with the teeth you are imaging. Then ask the patient to "slowly close." Try to say "slowly" first; avoid the word "bite." The command "bite down" may bring an unwanted response down on your fingers! If the film holder seems unstable because of the patient's occlusion, a cotton roll may be inserted under the holder, against the lower teeth if upper teeth are being imaged. Try not to allow the film to bend against the palate. Keeping the film in the highest portion of the vault and having the patient close gently will help to prevent film bending. Remember that a film that is placed parallel with the long axes of the teeth will not be parallel with the patient's midsagittal plane in the maxilla.

Mandibular films must be placed between the teeth and the patient's tongue. In order to capture the images of the apices of the teeth, the musculature in the floor of the mouth must be displaced by the film holder. This may be uncomfortable if the muscles are tense. In addition, the mucosa overlying the lingual aspect of the alveolar bone is thin, fragile, and easily abraded. Keeping your patient as comfortable as possible will make film placement easier.

Remember to keep the film away from the teeth and alveolar ridges. Place the film under the tongue at an angle, with the "elbow" of the film holder above the teeth. Gently depress the floor of the mouth while uprighting the film to a parallel position and ask the patient to "slowly close." As the patient starts to close his or her jaw, the floor of the mouth will drop slightly and the film holder should then contact the teeth to be imaged. As in the maxilla, a cotton roll may be used for stability, this time against the upper teeth.

Summary of Paralleling Film placement:

1. Film size: #1 anterior, #2 posterior.
2. White on white.
3. Dot in the slot.
4. Vertical anterior, horizontal posterior.
5. Bite-block in contact.
6. Cotton roll if opposing arch is edentulous.

Advantages of Paralleling Technique:

1. Dimensional accuracy.
2. Simple beam alignment.
3. Easier film duplication.

Disadvantages of Paralleling Technique:

1. Patient discomfort by the film holder.
2. Difficult film placement in a small mouth or shallow palate.
3. Longer exposure time.

Supplemental Periapical Techniques:

Bisecting Angle Technique, (Finger Holding Method, Digital Method):

Patient Preparation:

1. Infection control procedures.
2. Explain procedure.
3. Seat the patient.
4. Position the patient upright in the chair.
5. Adjust headrest.
6. Place lead apron, thyroid collar.
7. Remove all objects from the mouth.

The bisecting angle technique is based on the geometry of triangles. Two triangles will be equal if they share a common side and have two equal angles. This will make all corresponding sides equal. Therefore, a tooth and its image on the film will be equal in length if they share a common imaginary line between them.

To achieve the equal triangles, the film packet is placed close to the crowns of the teeth and extends at an angle into the palate or floor of the mouth. An angle is formed by the long axis of the teeth and the film. An imaginary line that bisects the angle creates two equal angles with a common side. If the x-ray beam is directed at 90° to the bisecting line, two equal triangles are formed.

The film packet should extend beyond the incisal or occlusal aspect of the teeth by about 1/8 to 1/4 inch. Film holders for bisection of the angle, including some with beam-alignment indicators, are available commercially. In a pinch, the film may be held in place by the patient's finger, but care must be taken to instruct the patient to use gentle pressure near the crowns to avoid bending the film.

Similar projections are used in the bisecting angle technique as in the paralleling technique. However, #2 size film is traditionally used in both the anterior (in a vertical orientation) and posterior (in a horizontal orientation) regions. All four maxillary incisors can be imaged on a #2 size film, so only three, as opposed to five, projections are needed in the maxillary anterior region. Beam alignment can be a challenge with bisection of the angle if film holders with alignment indicators are not used. The beam should pass between the contacts of the teeth being imaged in the horizontal dimension, just as it does in the paralleling technique. The vertical angle, however, must be directed at 90° to the imaginary bisecting line. Too much vertical inclination will produce images that are too short (foreshortened), and too little vertical inclination will result in images that are too long (elongated). The beam must be centered over the film to avoid cone cutting. A round PID is most often used when bisecting the angle; a rectangular PID greatly increases the chances of generating a partial image.

Usually a shorter (8-inch) PID (therefore shorter exposure times) is used when employing the bisecting angle technique.

Radiographers may have difficulty imagining the bisecting line and then directing the beam perpendicular to that bisector. Although the best results will be produced if each film placement in every patient is analyzed individually, the following guidelines may be helpful in allowing the radiographer to determine if he or she is approximating the correct beam alignment.

The patient's midsagittal plane should be perpendicular to the floor, and the occlusal plane of the arch that is being imaged should be parallel to the floor. This means that the patient's head is upright for maxillary films and tipped back slightly for the mandibular arch.

If these positioning requirements are met, the following vertical angulations will produce reasonable films for most patients:

Remember that a positive angulation occurs when the PID is tipped downward, and a negative angle occurs when the PID is tipped upward.

The advantage of the bisection of the angle technique is that it can be used when a patient's anatomy precludes the paralleling technique. For example, it is very difficult to place films in a position parallel to the teeth when the patient's palatal vault is very shallow.

The same holds true in the mandibular incisor area in a patient with a very short lingual frenum. It may also be difficult to correctly position films in a parallel position when there is a palatal or mandibular torus present. The major disadvantage of the technique lies in the fact that the image produced is not as accurate as that obtained with the paralleling technique. In addition, if a short, round PID is used, the patient is exposed to more ionizing radiation than when a long, rectangular PID is used. It is preferable to use the paralleling technique whenever possible, but diagnostic films can be obtained with the bisecting technique when necessary.

Advantages of Bisecting Angle Technique:

1. More comfortable; Film holder not essential.
2. Shorter exposure time.
3. Easier film placement in shallow palates, bony growths, shallow/tender floor of mouth.

Disadvantages of Bisecting Angle Technique:

1. Image distortion due to:
    a. Incorrect beam alignment.
    b. Patient using excessive force to stabilize the film.
    c. Short PID resulting in increased divergence of X-rays.
2. Harder beam alignment (without a film holder and aiming ring).
3. Film less stable (if a film holder isn’t used).
4. Unnecessary exposure of patient’s finger (if a film holder isn’t used).

Summary of Bisecting Technique:

Maxillary incisors:

At the tip of the nose.

+ 45 to +55

Maxillary canine:

At the ala of the nose.

+ 40 to +50

Maxillary premolars:

At the intersection of a vertical line passing through the pupil and the ala tragus line.

+ 30 to +40

Maxillary molars:

At the intersection of a vertical line passing through the outer canthus of the eye and the ala tragus line.

+ 20 to +30

Mandibular incisors:

At the chin.

20 to – 30

Mandibular canine:

At the intersection of a vertical line passing through the ala of the nose and a horizontal line 1 cm above the inferior border of mandible.

–15 to –25

Mandibular premolars:

At the intersection of a vertical line passing the pupil and a horizontal line 1 cm above the inferior border of mandible.

-10 to - 15

Mandibular molars:

At the intersection of a vertical line passing through the outer canthus of the eye and a horizontal line 1 cm above the inferior border of mandible.

-5 to 0

Positioning difficulties encountered in periapical radiography:

1. **Techniques for Children:**

Most children are eager to cooperate and respond very well to praise for a jop well done. You may, however, need to be extra patient and imaginative in some instances.

Demonstrating the equipment and explaining the procedure in detail before attempting the real thing will increase your level of success. Keep in mind that children have a very short attention span and have a hard time remaining still for any length of time, so work quickly yet accurately.

Young, growing tissues are particularly vulnerable to the effects of ionizing radiation. A lead apron and thyroid shield must be used each and every time a film is taken on a child.

Because of a child's smaller size, the exposure factors should be reduced; the ideal choice for exposure reduction is a decrease in the exposure time, because a shorter time will decrease the chance of movement artifact (blurring).

The type of radiographic survey needed for children is variable. Selection of the types, sizes, and quantity of films depends on the child's dental health, age, and ability to cooperate with the procedures.

2. **Techniques For Edentulous Patients:**

A completely edentulous patient may need radiographs for the detection of any pathologic lesion or the determination of the proximity of the maxillary sinuses or mandibular canals to the alveolar ridges.

A panoramic radiograph is an easy means of imaging edentulous arches, but periapical films can be obtained in edentulous areas as well. Either the bisecting angle or paralleling technique may be used. Shallow palate or loss of lingual sulcus depth contraindicates the paralleling technique. Periapical radiograph should be taken using a modified bisecting angle technique.

If paralleling instruments are used, cotton rolls may be used on the bite block for support and comfort. The "cotton roll" technique is also useful in partially edentulous patients, the deficiency can be built up using cotton rolls. Edentulous areas may require less exposure because of the absence of the teeth.

3. **Gagging:**

Obtaining diagnostic films on a gagging patient is a real challenge, and it is a relatively common problem encountered in intraoral radiography. The gag reflex is a physiologic one, but it can be influenced by a number of psychologic factors.

Some of the following management strategies may increase your chances of success.

Maintain an air of confidence in yourself. You may not always feel confident and in control, but it is important that the patient believes you have performed the procedure hundreds of times. Relax, and try to relax the patient with casual conversation. Explaining the procedure to the patient will eliminate surprises and reinforce the idea that you are familiar with the procedure to both the patient and yourself! Do not bring up the subject of gagging.

The power of suggestion is strong. The patient may say, "I'm a gagger," in which case you are forewarned and should bring out your best bag of tricks to control the situation. Start with the anterior periapical films; these are easily tolerated by most people, gaggers included. The fact that you can obtain these films will give you and the patient more confidence to try the posterior areas. Prepare the unit exposure factors and approximate placement of the tubehead before placing the film in the patient's mouth.

Be as gentle as possible, but place films accurately and quickly. There will be times when you will not be satisfied with the film placement, and it is perfectly acceptable to begin again. Placing the film exactly where you want it the first time eliminates small adjusting movements that may tickle the palate or tongue and elicit a gag reflex. Rubbing your finger in the area where the film will rest provides two functions: it lets the patient know where to expect the film, and it desensitizes the area somewhat.

If the patient gags, **remove the film and reassure the patient**. Some people are very embarrassed by the fact that they gag, and you need to assure them that it is not unusual.

Having the patient place some salt on his or her tongue or briefly dipping the film in some mouthwash may alleviate some gagging. Having the patient raise one foot may also work; the concentration of the patient on another activity decreases the attention paid to gagging. It may be helpful to have the patient breathe through his or her mouth while you place your finger for a few seconds in the area where the film will rest.

Because the patient must hold his or her breath in order to gag, **sustained breathing with an object in the mouth** usually will not elicit a gag reflex. Such a demonstration will convince patients that they are able to tolerate film placement. If you use breathing distractions, be sure the patient does not hyperventilate.

Topical anesthetic sprays may be used in severe cases. Caution must be used to ensure that the patient does not inhale the spray or that it is not placed too far down the throat to impair swallowing.

There are some people whose gag reflex is so strong that diagnostic quality intraoral films are impossible to obtain. **Extraoral films** are indicated for these individuals.

Summary of Gagging:

1. Patient sucking a local anesthetic lozenge before attempting to position the film packet.
2. Asking the patient to concentrate on breathing deeply while the film packet is in the mouth.
3. Placing the film packet flat in the mouth (in the occlusal plane) so it does not touch the palate and applying the principles of bisected angle technique.

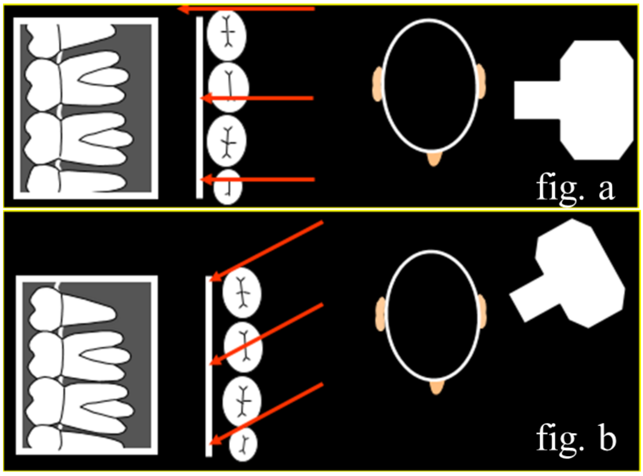
Mandibular third molars:

A needle holder is secured onto the top edge of the film packet. With the mouth open, the film packet is positioned gently in the lingual sulcus as far posteriorly as possible.

The patient is asked to close the mouth on to the handles of the holder (which relaxes the tissues of the floor of the mouth) and at the same time the film packet is eased further into the mouth until its front edge is opposite the mesial surface of the mandibular first molar. The patient is asked to support the handles of the needle holder in position.

X-ray tubehead is positioned at right angle to the film packet and centered 1 cm above the lower border of the mandible on a vertical line dropped from the outer corner of the eye.

Sometimes it is difficult to get the film far enough back to cover the third molar region due to gagging or anatomy, and all of the third molar will not be seen on the film (see fig. a). By rotating the tubehead so that the beam is directed more anteriorly (fig. b), the third molar is projected on to the film, giving us the needed information. Note, however, the increase in overlap that results.



Problems Encountered During Endodontics:

1. Film packet placement and stabilization when endodontic instruments are in position.
2. Identification and separation of root canals.
3. Assessing root canal lengths from foreshortened or elongated radiographs.

Film packet placement and stabilization when endodontic instruments are in position:

1. Taping the intraoral film packet to one end of a wooden tongue spatula. This is positioned in the mouth then held in place by the patient.
2. Using an endodontic film holder.

Assessing root canal lengths from foreshortened or elongated radiographs:

1. Taking an accurate paralleling technique periapical radiograph preoperatively and measuring the lengths of the roots directly from the radiograph before beginning the endodontic treatment. The amount of distortion on subsequent films can then be assessed.

2. Calculating mathematically the actual length of a root from a distorted bisected angle technique radiograph.

Actual Tooth Length = Radiographic tooth length x Actual instrument length/ Radiographic instrument length

Bitewing Radiographs:

Bitewing radiographs are probably the most common types of films ordered by the dentist for patients because of the nature of the information available on them. One can see the crowns of both the maxillary and mandibular teeth, the interproximal areas, and the crest of the alveolar bone, all on one film. Although producing a bitewing of diagnostic quality seems to be a relatively easy task, the technique is quite error-sensitive and can be challenging in some patients.

In general, two #2 size bitewings are taken per side of the patient: a premolar film and a molar film. Some practitioners may prefer one #3 size film per side, although the molars and premolars sometimes require different horizontal angulations in order to open the proximal contact areas.

Children often need only one #2 size bitewing per side, and small children with primary dentitions may require a #1 or #0 size film.

Film Placement:

The premolar bitewing radiograph should include the distal half of the crowns of the cuspids, both premolars, and often the first molars in both the maxilla and mandible. The molar film should be centered over the second molars. The films are held in place either with cardboard tabs or paralleling instruments.

Paralleling instruments decrease the amount of beam misalignment often seen on bitewings; however, the patient's teeth remain farther apart owing to the thickness of the bite block, and therefore less alveolar bone is seen with this method.

When tabs are used, the film should be placed so that the tab protrudes over the occlusal aspect of the mandibular teeth. The radiographer should hold the tab as the patient slowly closes. Placing a downward fold in the tab before placing the film may help in keeping the film in place. Take care not to let the patient catch the finger tip of your glove as he or she closes.

Additionally, do not pull the film too tightly against the lower teeth as the patient closes his or her mouth. The upper edge of the film may catch on the lingual aspect of the maxillary alveolar ridge or even the maxillary teeth, and the film will be forced down into the floor of the mouth. The upper half of the film should slide into the palatal vault so that both arches are equally covered by the film.

When using a paralleling instrument, the film should be placed away from the ridges so that the film and the holder will settle equally into the floor of the mouth and palatal vault. Placing the holder toward the midline of the oral cavity will also allow placement of the film forward enough to include the distal half of the cuspids in the premolar view.

If the film and holder are too close to the teeth, the holder will bump into the alveolar ridge where the arch curves in the vicinity of the cuspid, making capture of the cuspid image difficult. The film should be placed so that it parallels the alignment of the teeth in the arch.

Beam Alignment for Bitewings:

Beam alignment is fairly simple for bitewings taken with paralleling instruments. The beam should be aligned with the indicator ring and be parallel with the indicator bar, so that the beam is perpendicular to the film and passes through the contacts of the teeth. Beam alignment is more challenging when tabs are used.

The patient's midsagittal plane must be perpendicular to the floor, and the occlusal plane should be parallel to the floor. The vertical angulation should be set so that +10° is indicated on the tubehead. (Remember that a positive angulation means that the PID points downward.) This small vertical angle compensates for the fact that the upper half of the film tends to be lingually inclined against the palate. A vertical angulation of +10° places the beam so that it is nearly perpendicular to both the upper and lower halves of the film.

Correct horizontal angulation ensures that the contacts between the teeth being radiographed are open (not overlapped) on the film. The beam should be perpendicular to the film and pass directly between the contact points. The horizontal angles will be similar for the molar and premolar bitewings, although some adjustment may be necessary in moving from one to the other, because of the curvature of the dental arches. The beam must be centered over the film to avoid cone-cutting.

Occlusal Radiographs:

Occlusal films are often supplemental to periapical and bitewing films, they are useful when larger areas are to be visualized, for pediatric or edentulous patients, and to aid in the localization of a foreign object or impacted tooth. A #4 size film is used for adults; a #2 size film is often sufficient for children.

Occlusal radiography is intraoral radiographic techniques taken using a dental (X-ray) set where the image receptor is placed in the occlusal plane. The film packet 5.7*7.6cm.

Indications of occlusal radiography:

4. Periapical assessment of the upper anterior teeth for children unable to tolerate periapical holder.
5. Detecting the presence of unerupted teeth, supernumeraries and odontomes.
6. To visualize a relatively large segment of a dental arch.
7. To precisely located roots, supernumerary, unerupted, and impacted teeth especially canine and 3rd molar.
8. To identify expansion of cortical plate in case of any pathology such as cysts, tumors, and osteomyelitis.
9. Assessment of fractures of anterior teeth, alveolar bone, and maxilla and mandible.
10. To demonstrate and evaluate the integrity of the outline of maxillary sinus, and localization of object.
11. To aid in examining patients with Trismus who can open their mouth only a few millimeters.
12. To study expansion of palatal arch during orthodontic jaw expansion procedure.
13. To locate salivary stones in the duct of the submandibular gland.
14. To examine cleft palate.

Topographic Maxillary Occlusal Film:

The topographic occlusal film is taken with a technique similar to bisecting the angle. For the maxillary radiograph, the patient's maxillary arch should be parallel to the floor and the midsagittal plane perpendicular to the floor. The film is placed in the mouth, white side against the maxillary teeth, and the patient should gently close on the film.

The beam should be directed so that the vertical angle is perpendicular to the imaginary line bisecting the angle formed by the maxillary incisors and the film. This angle will be approximately +65° to +75°. The horizontal angle should be such that the beam passes between the central incisors. The PID should be centered over the film. A round PID will allow greater coverage of the film and anatomic structures than a rectangular PID. Exposure factors will be similar to those for a maxillary incisor periapical film.

Topographic Mandibular (Occlusal Film):

The mandibular dental arch should be parallel to the floor, and the midsagittal plane should be perpendicular to the floor. The occlusal film is placed with the white side against the mandibular teeth, and the patient gently closes on the film packet. The vertical angulation of the bean should correspond to the bisecting angle principle and will approximate –300– 40. The beam should be centered over the film and pass through the prominent chin point (mentum). Exposure factors are similar to those for a mandibular incisor periapical film.

Maxillary Lateral Occlusal View:

The lateral occlusal view allows a topographic view of the more posterior aspect of the maxillary arch. This view is generally not employed in the mandible. A lateral oblique jaw projection provides similar coverage in the mandible.

In the maxillary lateral occlusal view, the patient's occlusal plane is parallel to the floor and the midsagittal plane is perpendicular to the floor. The film is placed with the white side against the teeth and positions so that the longest dimension of the film extends toward the molars. The edge of the film should extend about 1/4 to 1/2 inch beyond the cusp tips of the molars.

The beam is directed at a vertical angle of about +60° to +65° and centered over the film so that the center of the beam passes between the proximal contacts, similar to a periapical film. The exposure factors are similar to those for a molar periapical film

Cross-Sectional Mandibular (Occlusal View):

Cross-sectional or true occlusal views are of value for examining the buccal-lingual dimension of the mandible or to evaluate the presence of objects in the floor of the mouth.

Cross-sectional views in the maxilla are difficult to obtain, because a beam that is perpendicular to the maxilla would have to pass through the top of the cranium. In a cross-sectional view, the patient's midsagittal plane should be perpendicular to the floor. The position of the occlusal plane is less critical, because the beam is directed 90° to the film. In fact, it is often easier to have the patient tip the head backward somewhat.

The film is placed with the white side against the mandibular teeth. It may be positioned with the long axis in a buccal-lingual direction for imaging the more anterior portions, or it may be directed with the long axis toward the molar region, often over only the left or right side of the jaw.

The beam should be centered over the film with a vertical angle of 90° to the film. Exposure factors should be similar to a mandibular periapical film. Slightly less exposure is required for a soft-tissue examination of the floor of the mouth.

REFERENCES:

1. Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The Essential Physics of Medical Imaging: Lippincott Williams & Wilkins; 2011.
2. Richard R. Carlton, Arlene McKenna Adler (2005) Principles of Radiographic Imaging, Delmar.
3. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.

Panoramic Radiography

L.12 Panoramic Technique

By

Mahmood Al-Fahdawi B.S., M.Sc., Ph.D.

Oral Radiology Teacher, Anbar University

A panoramic radiograph is a panoramic scanning dental X-ray of the upper and lower jaw. It shows a two-dimensional view of a half-circle from ear to ear. Panoramic radiography is a form of focal plane tomography; thus, images of multiple planes are taken to make up the composite panoramic image, where the maxilla and mandible are in the focal trough and the structures that are superficial and deep to the trough are blurred.

Indications:

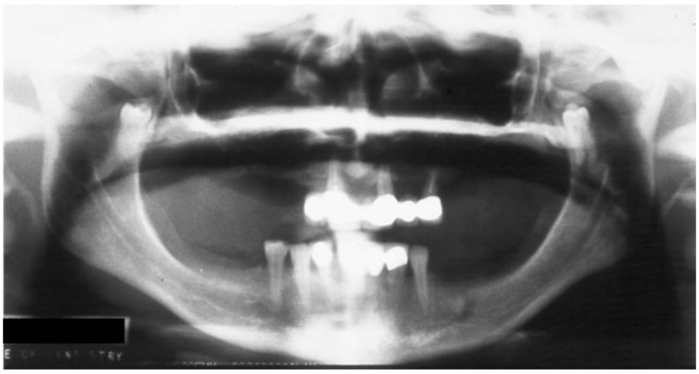
Orthopantomograms (OPTs) are used by health care professionals to provide information on:

1. Impacted wisdom teeth diagnosis and treatment planning - the most common use is to determine the status of wisdom teeth and trauma to the jaws.
2. Periodontal bone loss and periapical involvement.
3. Finding the source of dental pain, and when carrying out tooth-by-tooth diagnosis.
4. Assessment for the placement of dental implants
5. Orthodontic assessment. Pre and post-operative
6. Diagnosis of developmental anomalies such as cherubism, cleido cranial dysplasia
7. Carcinoma in relation to the jaws
8. Temporomandibular joint dysfunctions and ankylosis.
9. Diagnosis of osteosarcoma, ameloblastoma, renal osteodystrophy affecting jaws and hypophosphatemia.
10. Diagnosis, and pre- and post-surgical assessment of oral and maxillofacial trauma, e.g. dentoalveolar fractures and mandibular fractures.
11. Salivary stones (Sialolithiasis).
12. Other diagnostic and treatment applications.

Third Molars:

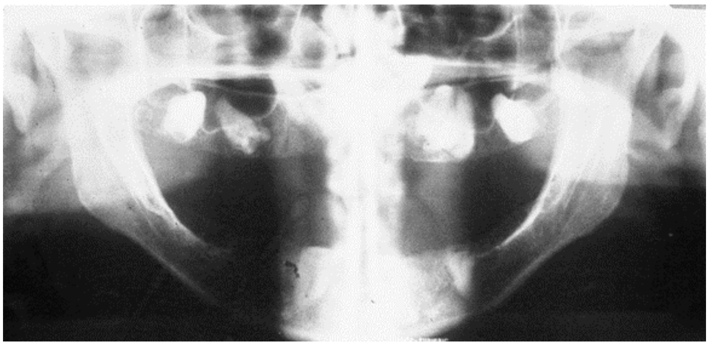
The identification of the location and orientation of third molars is one of the most common uses of panoramic films.

In this film, the mandibular third molars have migrated up into the coronoid process region.



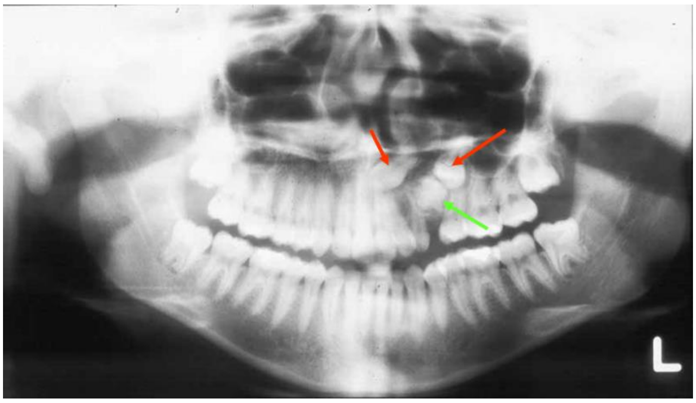
Impactions:

This film demonstrates the importance of having the proper diagnostic information before deciding on a treatment plan. This patient had numerous impacted teeth and several associated cysts. The patient had been wearing dentures for many years and was unaware of the impactions.



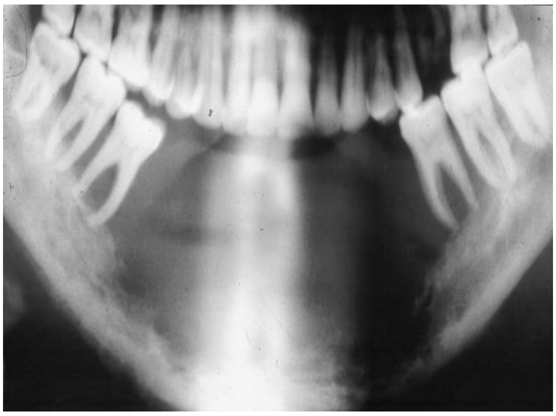
Pathology:

In this patient, tooth numbers 11 and 12 did not erupt. The film shows the location of these unerupted teeth (red arrows) and also identifies the presence of a complex odontoma (green arrow) which contributed to the failure of the teeth to erupt.



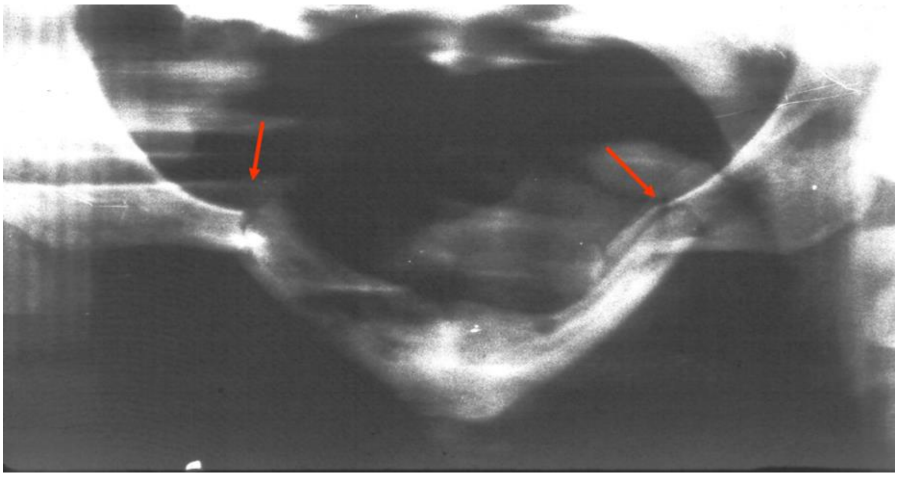
This patient has a very large dentigerous cyst which involves the entire ramus and extends forward to the second premolar region.

This film shows the extensive destruction of the mandible caused by a metastatic carcinoma.



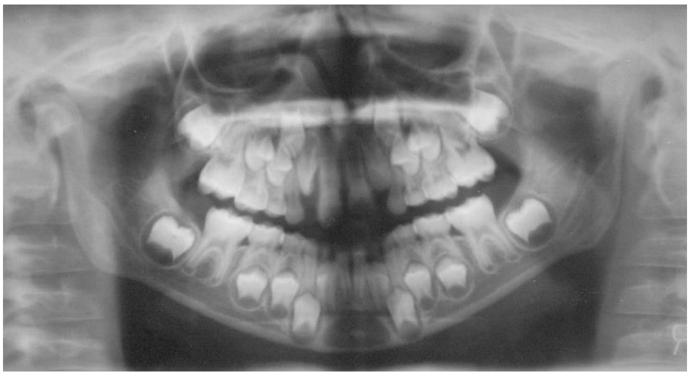
Fractures:

As a result of trauma, this patient has bilateral fractures of the mandible (red arrows).



Mixed Dentition:

Unerupted permanent teeth in a child are easily seen on a panoramic film. Missing permanent teeth or supernumerary teeth can be readily identified.



Advantages:

1. Short time required for making the image.
2. Broad coverage of facial bone and teeth.
3. Exposes the patient to less radiation (one third the dose from an intraoral full mouth survey).
4. Field limitation techniques result in further dose reduction.
5. Requires less technical expertise.
6. Convenience of examination for the patient (films need not be placed inside the mouth). Easily tolerated by the patient.
7. Can be used when the patient is unable to open his mouth.
8. Patient's ready understandability of panoramic films, making them a useful visual aid in patient education and case presentation (easy for the patients to understand).
9. Patient movement distorts only that part of the image being produced at that instant.
10. Shows both sides of the mandible on one film which is useful when assessing fractures.
11. Shows the floor, anterior and posterior walls of maxillary sinus bilaterally.
12. Shows both condylar heads on one film.

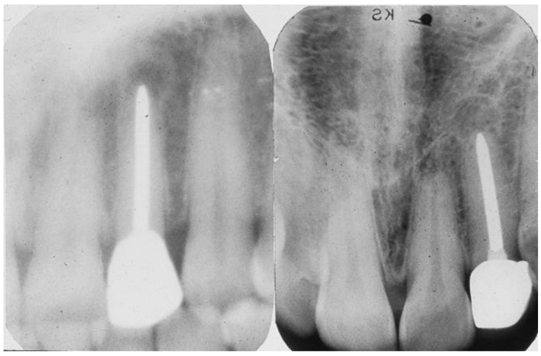
Disadvantages:

1. Produces an image that is less sharp.
2. May not reveal objects that are outside the focal trough.
3. Requires more expensive equipment.
4. Soft tissue and air shadows can overlie the required hard tissue structures.
5. Ghost shadows can overlie the structures in the focal trough.

6. Image magnification (app. 1.3 times) and distortion due to tomographic movement and the distance between the focal trough and film.
7. Not suitable for children under five years and some disabled patients because of the length of the exposure and the need for the patient to stay still.
8. Some patients do not conform to the shape of the focal trough.

Sharpness:

The sharpness or detail seen on a periapical film is much better than that seen on a panoramic film. The images are "fuzzier" on a panoramic film and are not good for diagnosing early pathology.



panoramic periapical

A periapical or bitewing film is preferred over a panoramic film for:

1. Caries.
2. Periodontal disease.
3. Early or limited periapical pathology.
4. Endo treatment.

– The panoramic radiograph should not be used as a substitute for intraoral films.

Dental panoramic tomography has become a very popular radiographic technique in dentistry. The main reasons for this are as follows:

1. All the teeth and their supporting structures are shown on one film.
2. The technique is reasonably simple.
3. The radiation dose is relatively low, particularly with modern DC units with rare-earth intensifying screens, the dose is equivalent to about 3–4 periapical radiographs.

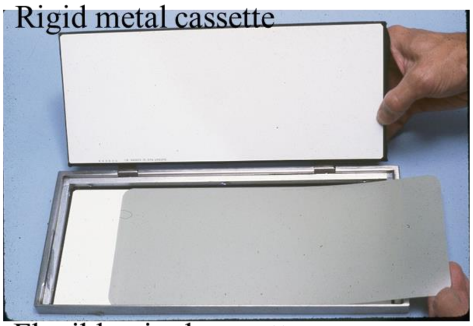
Panoramic Machines:

There are several manufacturers of panoramic equipment. Most of the units are designed for a patient to stand, but they will also accommodate a patient seated on a stool or in a wheelchair. For some machines, the tubehead always starts out on the same side of the patient (either left or right); for other machines, the tubehead can start from either side (varies from one patient to the next).

Cassette/Screens/Film:

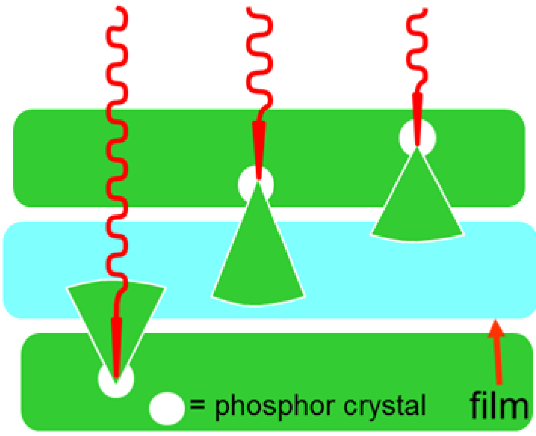
A light-tight cassette is used to hold the x-ray film in tight contact with two intensifying screens (one on each side of the film). The cassette can be either rigid metal or soft vinyl, depending on the type of panoramic machine.

A light-tight cassette is used to hold the x-ray film in tight contact with two intensifying screens (one on each side of the film). The cassette can be either rigid metal or soft vinyl, depending on the type of panoramic machine.



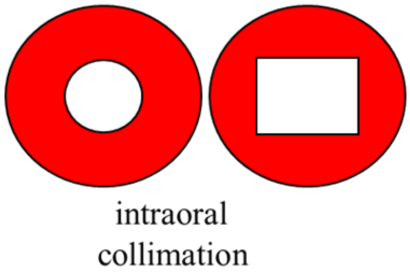
Screens/Film:

Most of the intensifying screens used for panoramic radiography emit green light. The phosphor crystals on the screens emit green light when struck by x-rays. This light in turn exposes the film, which is sensitive to green light. T-MAT or Ektavision film are two types of film used for panoramic radiography.



Collimation:

In order to limit the exposure to the patient, the x-ray beam is collimated. The collimator controls the size and shape of the x-ray beam. Intraorally, the x-ray beam is either round or rectangular and is large enough to cover the entire intraoral film. The collimator for panoramic radiography produces a narrow, rectangular x-ray beam that exposes a small portion of the film as the tubehead and film rotate around the patient.



Tomography:

Tomography is a radiographic technique that allows imaging of one layer or section of the body while blurring images from structures in other planes.

During tomography, the equipment is designed to move in one of five ways: linear, circular, elliptical, spiral and hypocycloidal.

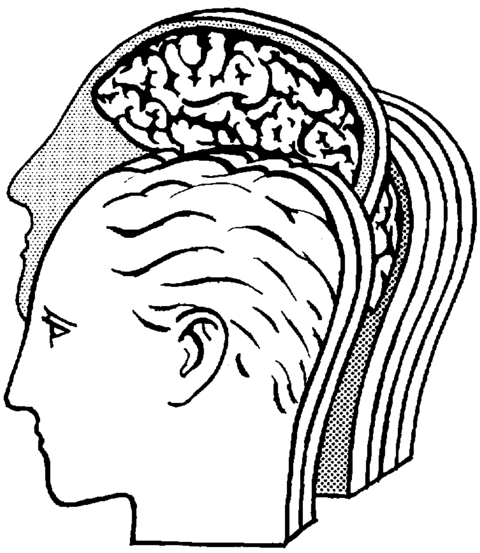
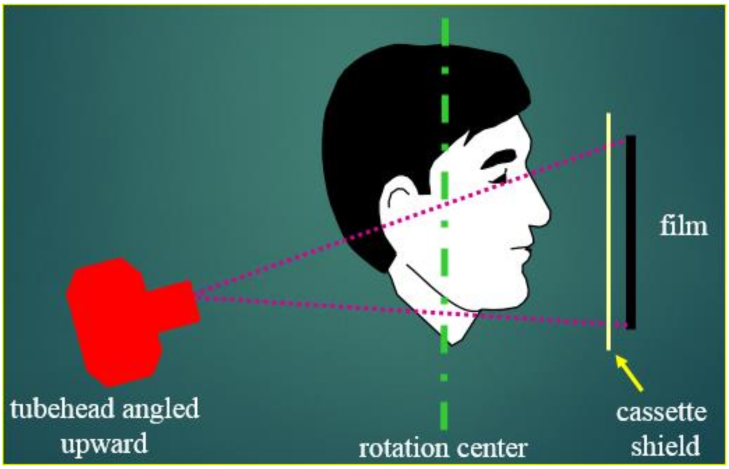


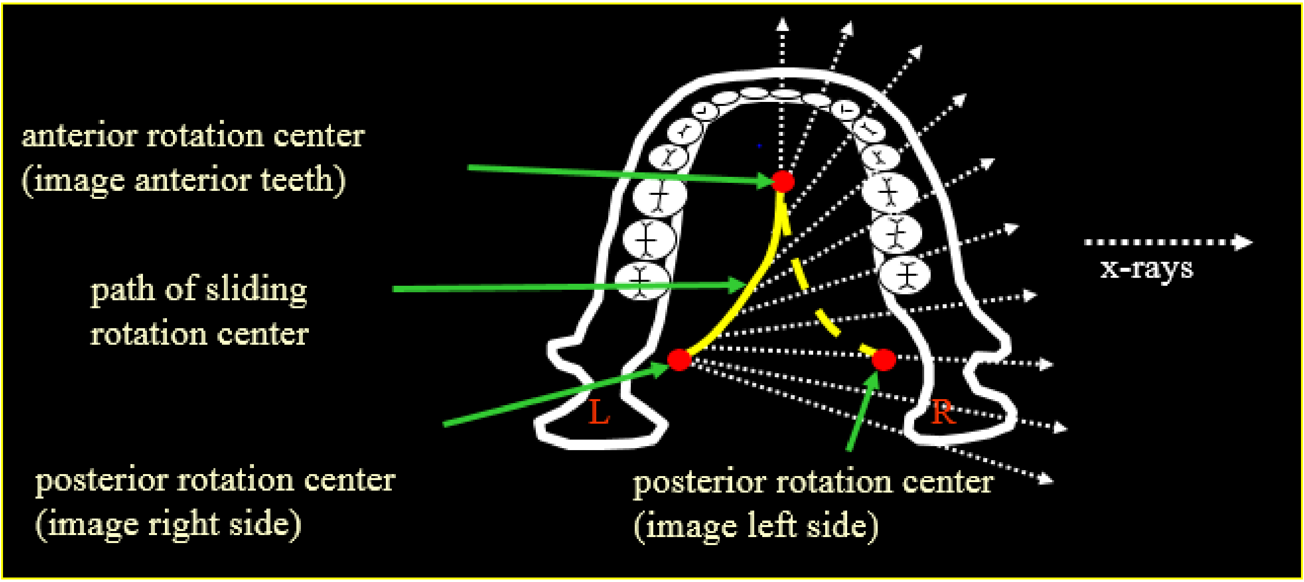
Fig. 14.1 Diagram illustrating the analogy of tomography dividing the patient up like a loaf of sliced bread.

Rotation Center:

- The tubehead rotates in an arc around the back of the patient's head.
- The film rotates in front of the patient.
- The center of this rotation varies as the tubehead rotates, producing a sliding rotation center.
- The vertical angulation cannot be varied. The X-ray beam is directed slightly upwards.



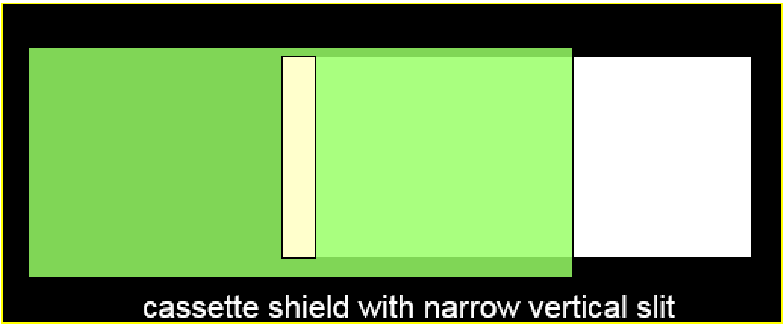
Sliding Rotation Center:



At the starting point with the tubehead on the patient's left, the rotation center is located posteriorly, on the same side as the tubehead, as shown below. As the tubehead moves behind the patient, the rotation center "slides" toward the front. As the tubehead continues to move to the patient's right, the rotation center "slides" back posteriorly.

Tubehead Rotation:

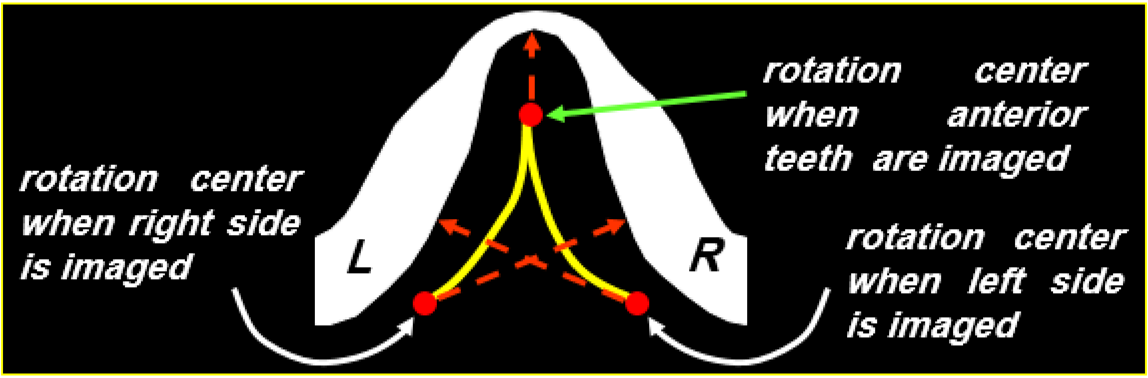
As the tubehead rotates around the patient, the cassette holder is also rotating so that it is always lined up with the x-ray beam. The x-ray beam passes through a narrow vertical opening in the cassette shield, which allows only a small portion of the film to be exposed at a time. The film/cassette slides within this shield, constantly exposing different parts of the film as the whole unit rotates.



As the tubehead rotates around the patient, the x-ray beam passes through different parts of the jaws, producing multiple images that appear as one continuous image on the film ("panoramic view").

Focal Trough (Image layer):

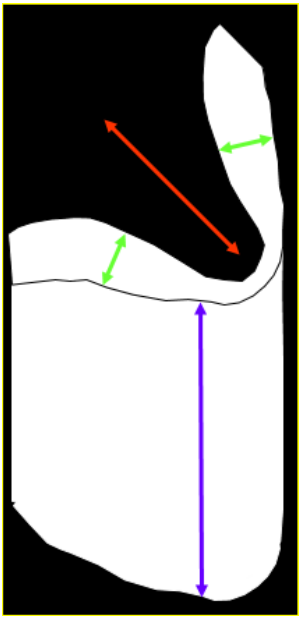
The focal trough is a three-dimensional curved zone or image layer in which structures are reasonably well defined. Through the design of the panoramic machine, this zone corresponds to the shape of the upper and lower jaws. The shape and width of the focal trough is determined by the path of the sliding rotation center. The closer the rotation center is to the teeth, the narrower the focal trough in that area. Because the rotation center is closer to the anterior teeth, the focal trough is narrower in this area.



The three dimensions of the focal trough are:

1. Front-to-back (anterior-posterior). Red arrow.
2. Side-to-side (buccolingual). Green arrows.
3. Up-and-down (Vertical). Blue arrow.

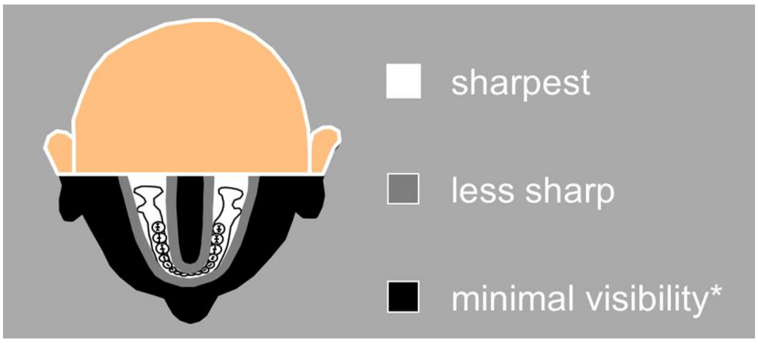
The quality of the resulting panoramic radiograph depends on the positioning of the patient's teeth within the focal trough and how closely the patient's jaws conform to the focal trough designed for the average jaw



Sharpness:

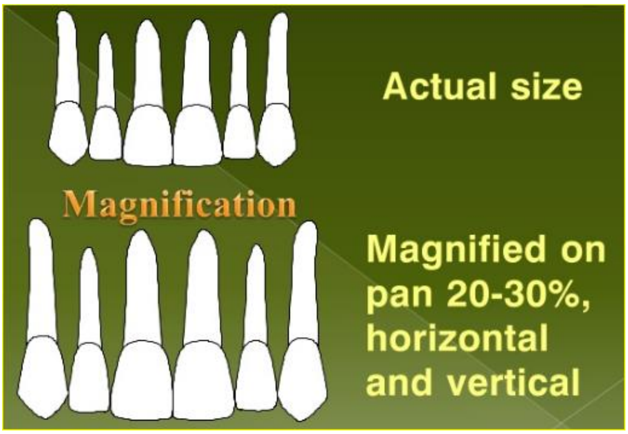
The sharpness of objects will vary depending on their location relative to the focal trough.

* The images of objects with minimal tissue density are blurred and are not easily seen on the film. Dense objects, such as a bullet fragment, will still be seen.



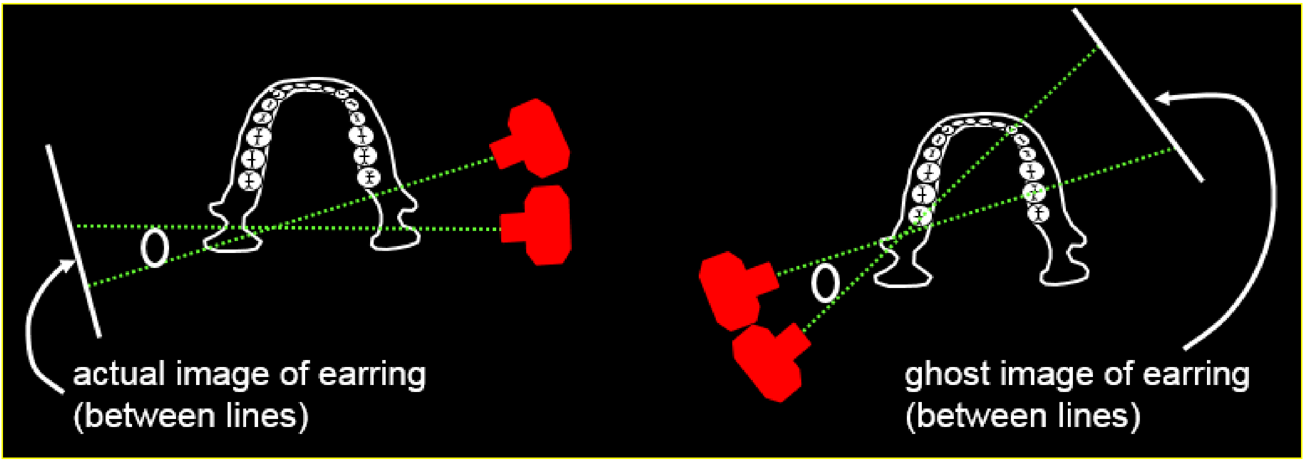
Magnification:

Objects in the focal trough will be magnified in both the horizontal and vertical dimensions. The overall magnification will be 20-30%.

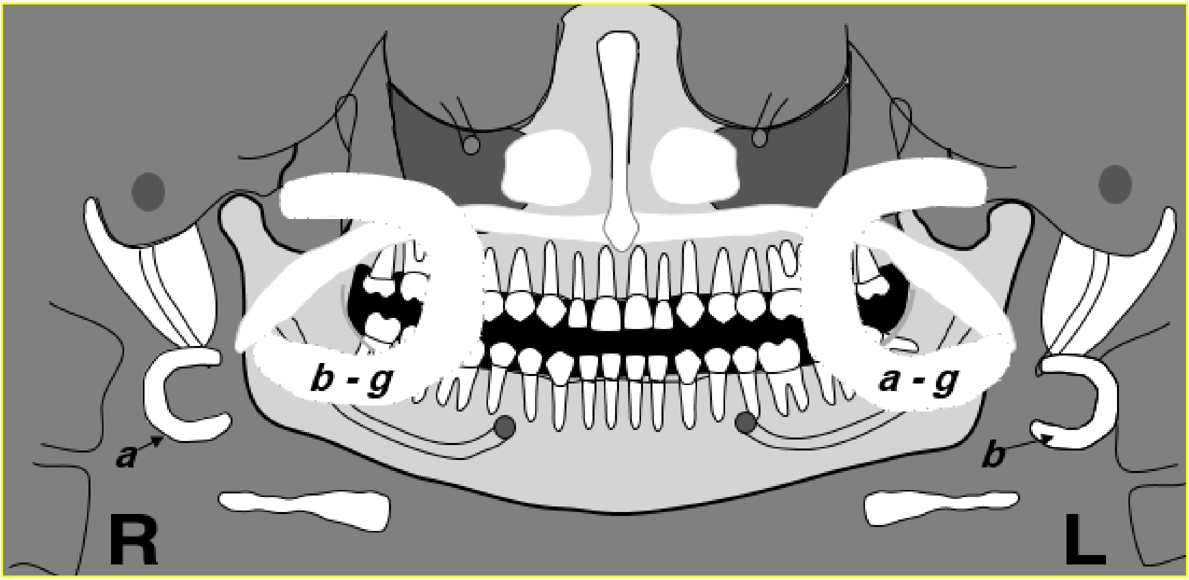


Ghost image:

A ghost image is the opaque shadow of a dense object (jewelry, anatomy) located on the opposite side of the patient. E.g., the ghost image of an earring in the patient's right ear will be seen in the maxillary left region on the film.



In the diagram below, the ghost image b-g is created by the earring b and a-g is produced by the earring a.



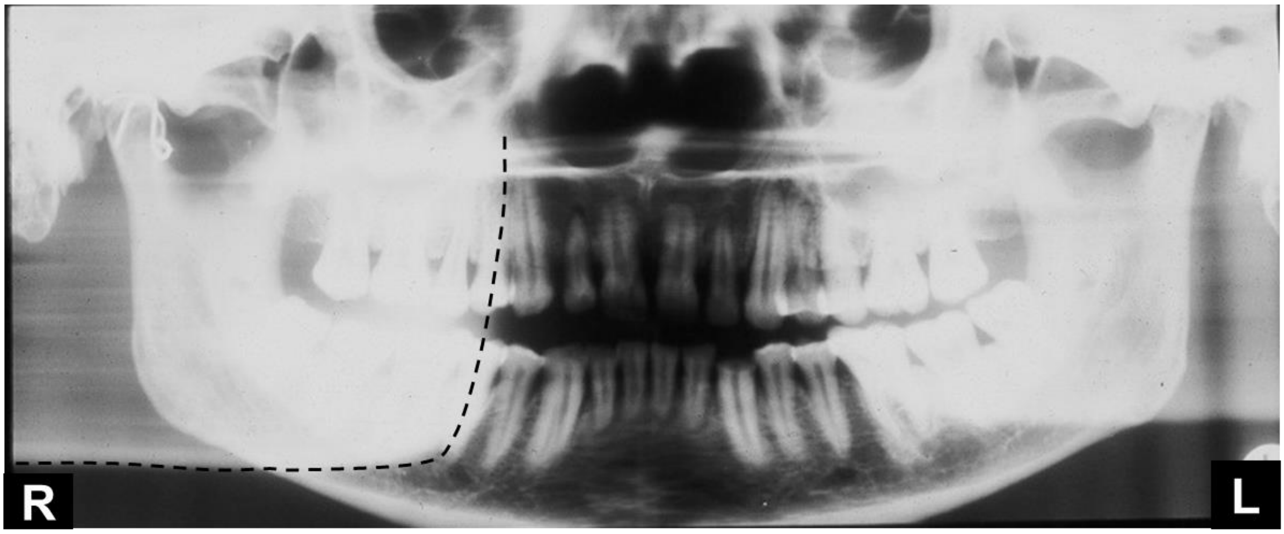
Characteristics of a Ghost Image:

A ghost image will be:

1. Located on the opposite side from the image of the actual object.
2. The same shape as the actual object.
3. Larger than the image of the actual object.
4. Projected higher on the film.
5. Blurred (less sharpness; “ghostlike”).

The earring indicated by the red arrow left (patient's right ear) produced the ghost image indicated by the green arrow.

The dotted line below outlines the shape of the ghost image of the left side of the mandible. Because it is very dense bone, this normal anatomy can produce a ghost image.



Patient Exposure:

The exposure from a panoramic film is approximately equal to that from four intraoral films. Because of this relatively low dose and the extensive area covered, the panoramic film is a very popular choice when combined with bitewings and selected periapical films.

Panoramic Technique:

Equipment Setup:

Load the film between screens (in the darkroom) and position the cassette in the machine.

Patient Preparation:

Patient preparation is extremely important for ensuring that a high-quality image is produced and that errors are avoided (the following table). For instance, incorrect patient preparation can lead to "ghost images" which can render the radiographic image undiagnostic. While ghost images often occur due to metallic objects, they can also occur due to anatomical structures located outside the image layer or focal trough. Ghost images always appear higher and distorted on the opposite side of the radiographic image (see below figure). Some errors are unavoidable due to the patient's stature, facial asymmetry, or difficulty following instructions.

Patient Preparation Guidelines.

Jewelry	All necklaces, piercings (earrings, tongue rings, etc.) and jewelry in the head and neck regions need to be removed prior to exposure.
Metal objects	Items such as headbands, bobby pins, hair clips, hearing aids, etc. must be removed prior to exposure. Removable partial dentures and orthodontic appliances should be taken out prior to imaging. Basically, remove anything between the neck and the top of the ears. Berets, etc., above the top of the ears will not be seen on the film. The two patients below would have some difficulties doing this.
Lead Apron	Apron must not have a thyroid collar and should be placed properly so it does not block the x-ray beam.

An important item to include when preparing the patient is the use of a lead apron, which is recommended for all radiographic procedures. Lead aprons help provide protection for radiosensitive tissues in the neck, chest, reproductive areas, and blood forming tissue. In addition, lead aprons stop nearly 98% of scattered radiation from reaching reproductive organs. There are lead-free aprons that use an alloy material instead of lead. They are 50% lighter and safer for patients and clinicians because they are lead-free.

While thyroid collars are not indicated for panoramic imaging, they are effective for use during intraoral imaging, because they have been shown to stop 92% of scatter radiation. One study revealed that only 2% of the general dentists surveyed report using a lead apron with a thyroid shield prior to taking radiographs.

Place the lead apron on the patient (no thyroid collar; it might block part of the x-ray beam). An apron with equal sides is usually used to protect the patient. Make sure the apron is positioned low on the back of the patient's neck (arrow) so that it does not block the beam as the tubehead rotates behind the patient.

A poncho style lead apron protects the front and back of the patient.

Patient Positioning:

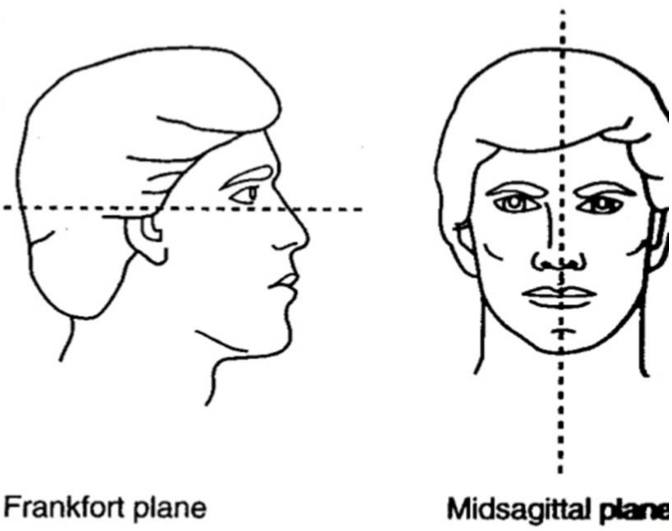
No matter the type of panoramic machine, there are four basic steps in patient positioning.

1. The maxillary and mandibular incisors are placed in the notch of the bitestick. This positions the anterior teeth in the focal trough.
2. The Frankfort Plane should be parallel to the floor.
3. The Midsagittal Plane is perpendicular to the floor and centered on the bitestick.
4. The vertebral column should be straight.

Reference Lines:

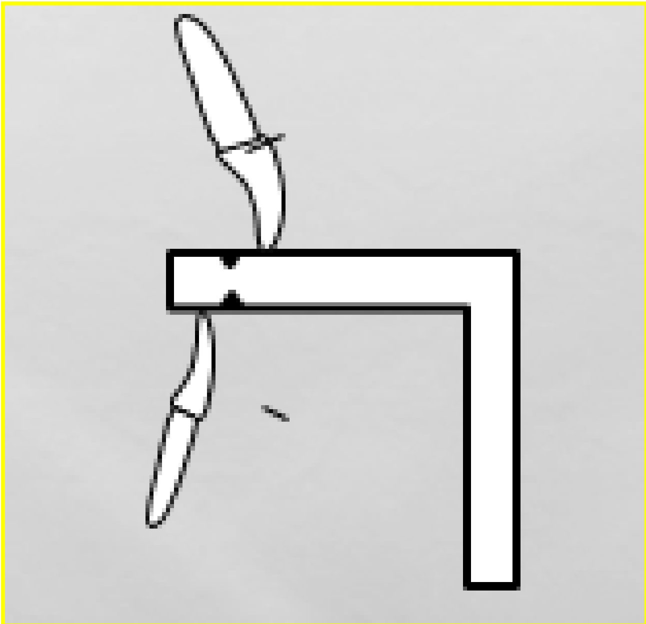
Frankfort Plane: represented by a line from the inferior border of the orbit to the top of the external auditory meatus.

Midsagittal Plane: divides the head into right and left halves.

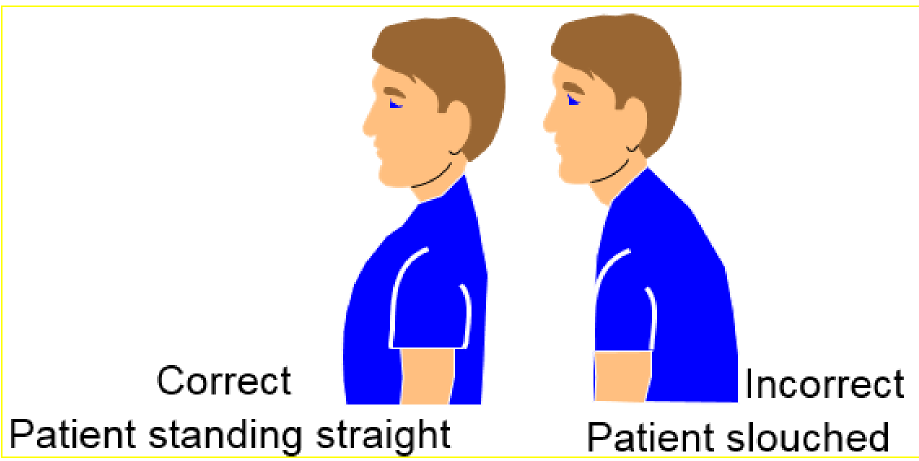


For edentulous patients, align the anterior edentulous ridges with the notches in the bitestick. Have the patient close gently.

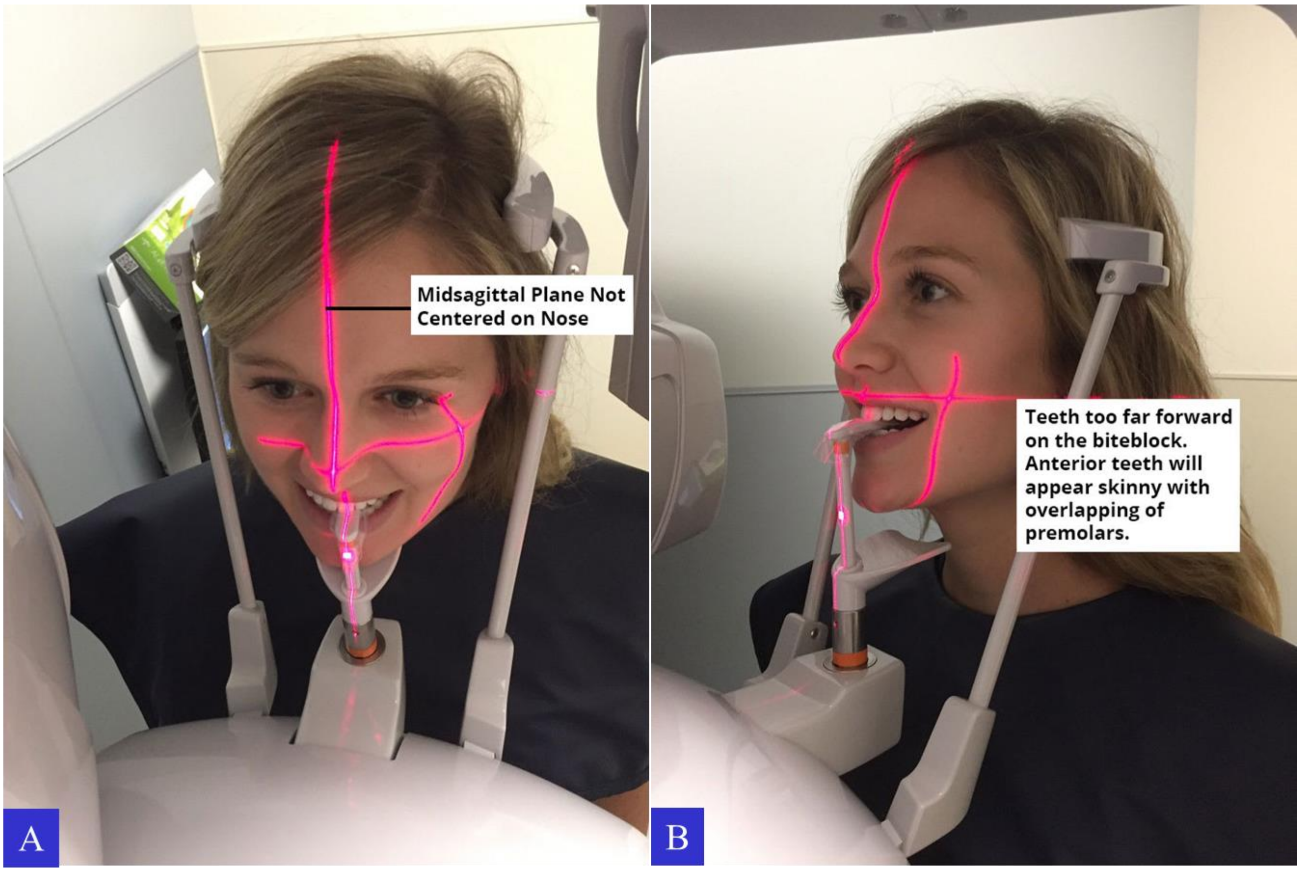
For patients with severe Class II or Class III occlusion, align the front teeth as closely as possible with notches. Split the difference between the two if both arches cannot be aligned in the notches.



The patient is encouraged to stand straight. Since the x-ray beam is angled upward, it may pass through the vertebra if the patient is "slouched", creating a white shadow on the film.



Just before you are ready to begin the exposure sequence, advice the patient to swallow and feel the tongue contact the palate. Tell the patient to maintain this contact the entire time of the exposure (approximately 20 seconds). If they have a hard understanding this, just tell them to force as much of their tongue as possible against the roof of the mouth and hold it there. Advise the patient to keep the head still during the entire exposure.



(A) Example of incorrect patient positioning, because the midsagittal plane is not centered along the midline of the face. (B) Example of correct patient positioning with the tongue pressed against the palate, teeth in the groove of the bite-block, and the indicator light for the midsagittal plane centered and perpendicular to the floor.

If patient positioning is incorrect, errors are likely to occur. Patient positioning errors are the most common type of error when performing panoramic radiography.

The most common patient positioning error occurs when the tongue is not placed close enough to the palate. This may be due to the patient misunderstanding the instructions and only placing the tip of their tongue on the palate. Incorrect positioning of the tongue creates radiolucency near the apices on the maxilla, which makes diagnosis of periodontitis and root resorption challenging.

It is helpful to note that each manufacturer provides specific operation instructions in the manual that accompanies the unit. It is worth the time and effort for each team member to become acquainted with the contents of the manual. While the instructions make panoramic imaging easy to perform well, it is equally as easy to perform badly when manufacturers' instructions are not followed. Proper patient positioning (the following table) will help reduce the possibility of errors in panoramic imaging.

Patient Positioning Guidelines.

Standing/Sitting	If patient is able to stand, have them stand erect without the spine being slumped. If patient is seated, they should sit as upright as possible. It helps to do a test run with the panoramic machine to make sure it will not hit the patient's shoulders.
Mouth position	Patient needs to place maxillary/mandibular incisors correctly on bite block in order to achieve proper alignment of the teeth. Most units have a notch in the bite block indicating the proper location for the patient to bite.
Midsagittal Plane	The patient's head must be straight & not tilted. The midsagittal plane must be kept perpendicular to the floor.
Frankfort Plane	Keep the Frankfort plane parallel with the floor.
Tongue	Instruct the patient to place their entire tongue on the hard palate and leave it there for the duration of the exposure.
Lips	Instruct patient to keep their lips together for the duration of the exposure.
Eye	Have patient close their eyes so they do not follow the movement of the tube head.

Exposure Settings:

The kVp and mA can be adjusted on panoramic machines. Exposure time is fixed and cannot be changed. The larger the patient, the higher the settings need to be.

Follow the manufacturer's suggestions for varying the exposure settings based on patient size. Using these guidelines and recognizing adjustments you need to make based on experience, you should have no problems selecting the correct exposure factors for your patients.

Exposure:

Complete the exposure by depressing the exposure button and holding it down until the x-ray tube has completed its arc and has come to a stop. Some machines have an audible signal that indicates the completion of the exposure.

Infection Control:

The cover is placed on the bitestick before patient positioning. After exposure, the cover is removed and discarded. Following this, the bitestick and all surfaces that contacted the patient's head should be wiped with a disinfectant.

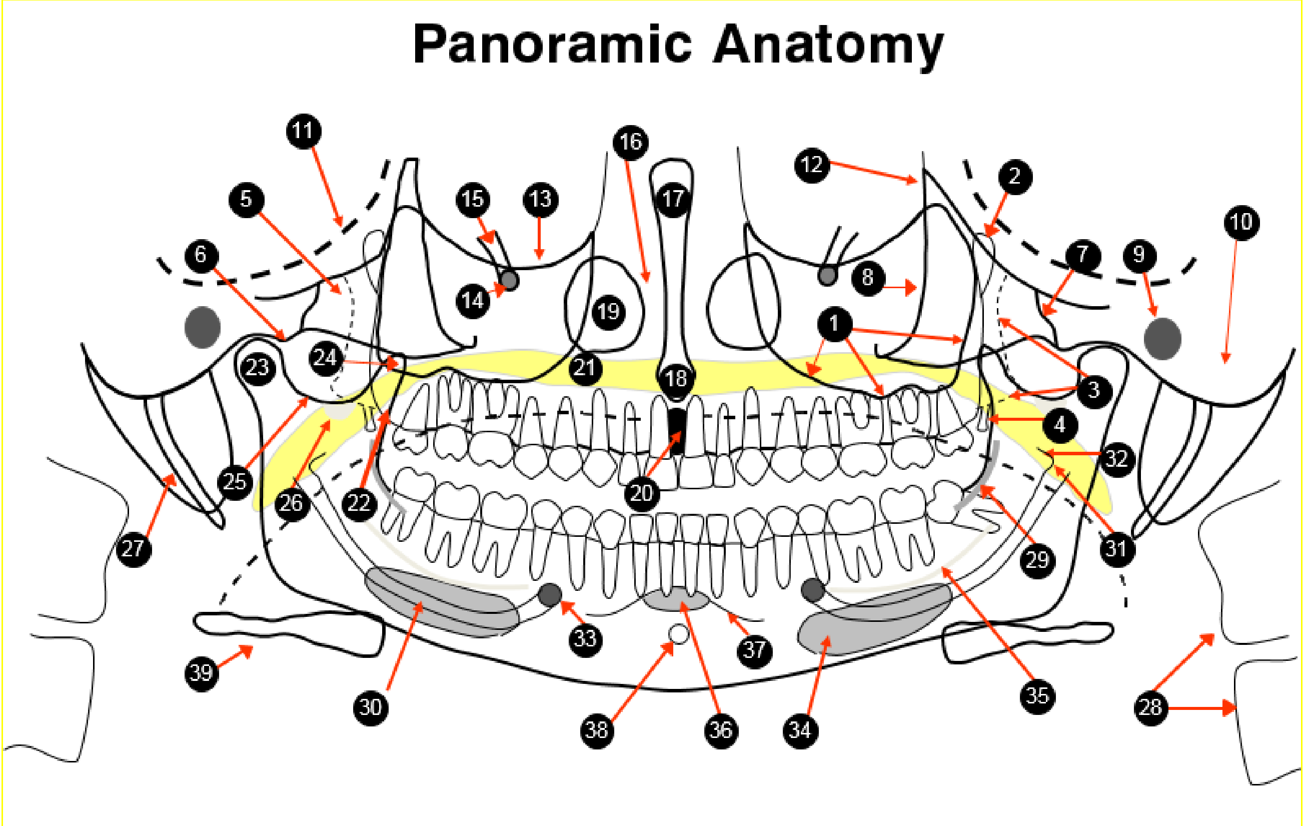
Types of Panoramic Image:

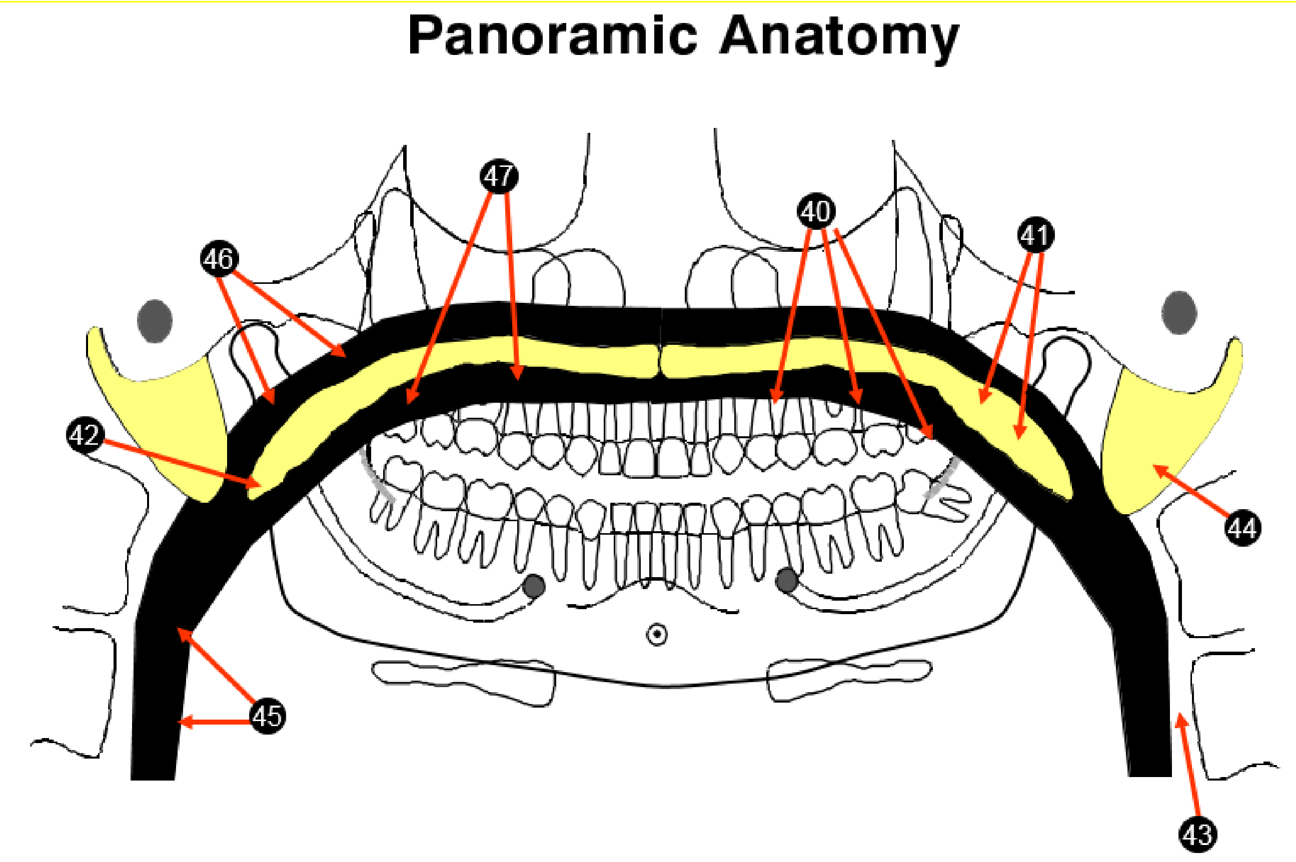
Single Real Image: Only one image results from a given anatomical structure. Most images seen on a panoramic film are of this type. The object is between the center of rotation and the film.

Double Real Image: Two images of a single object which is located in the midline. Structures that produce these double real images include the hard & soft palate, hyoid bone and cervical spine. Object is between the center of rotation and the film.

Ghost Image: Usually caused by external objects such as earrings but may be produced by dense anatomical structures such as the mandible. Objects located between center of rotation and X-ray source.

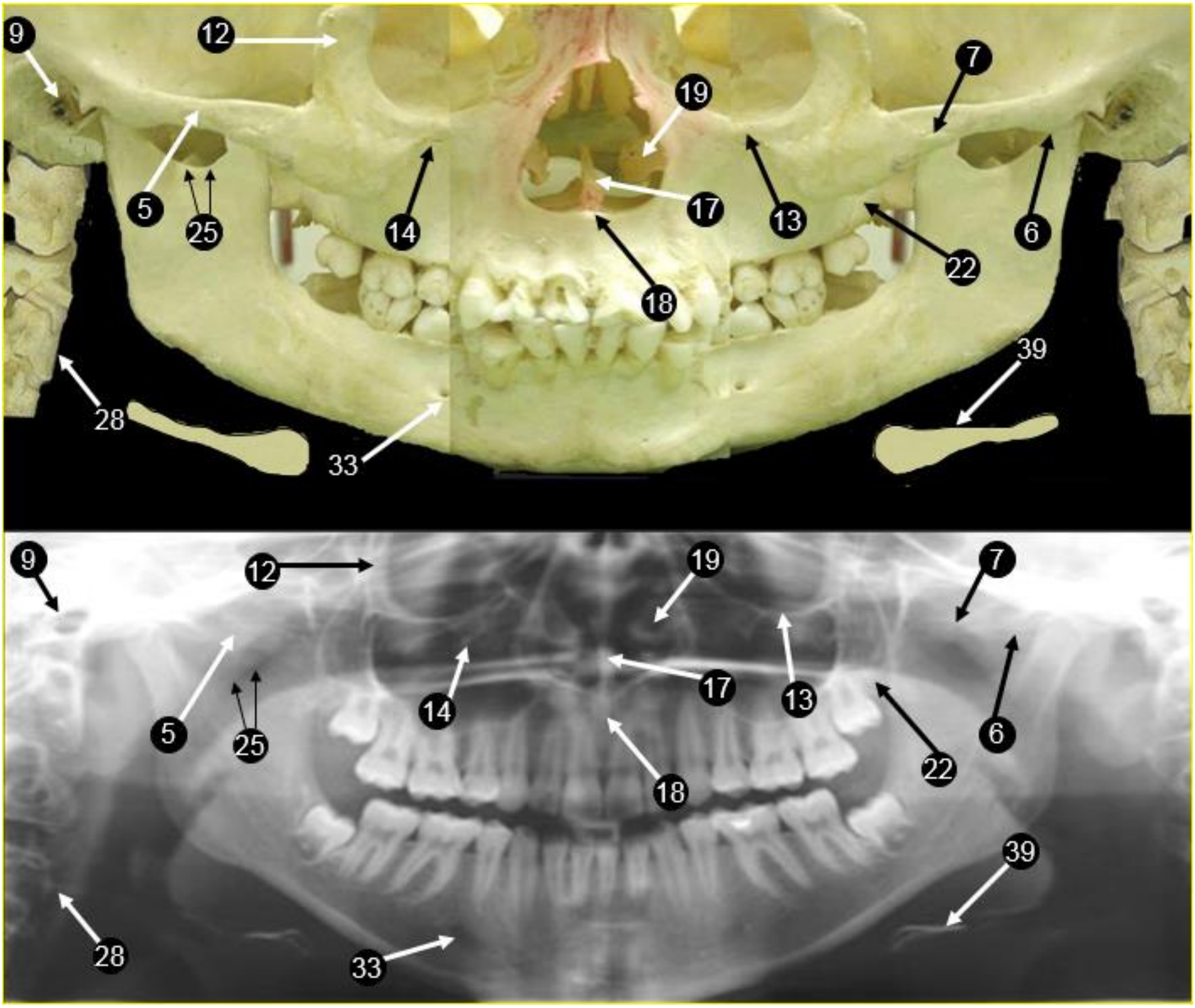
L.13 **Panoramic Anatomy**

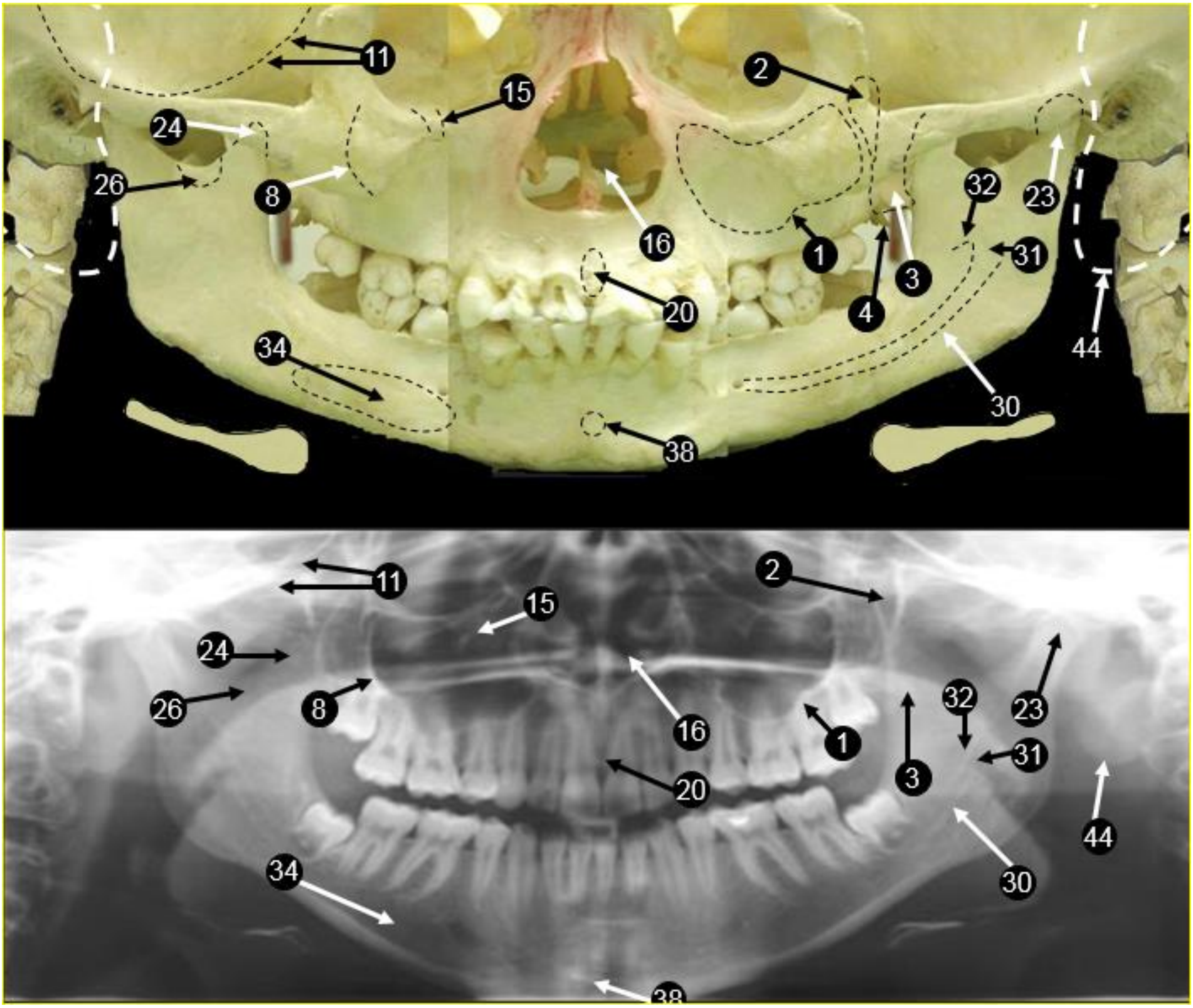


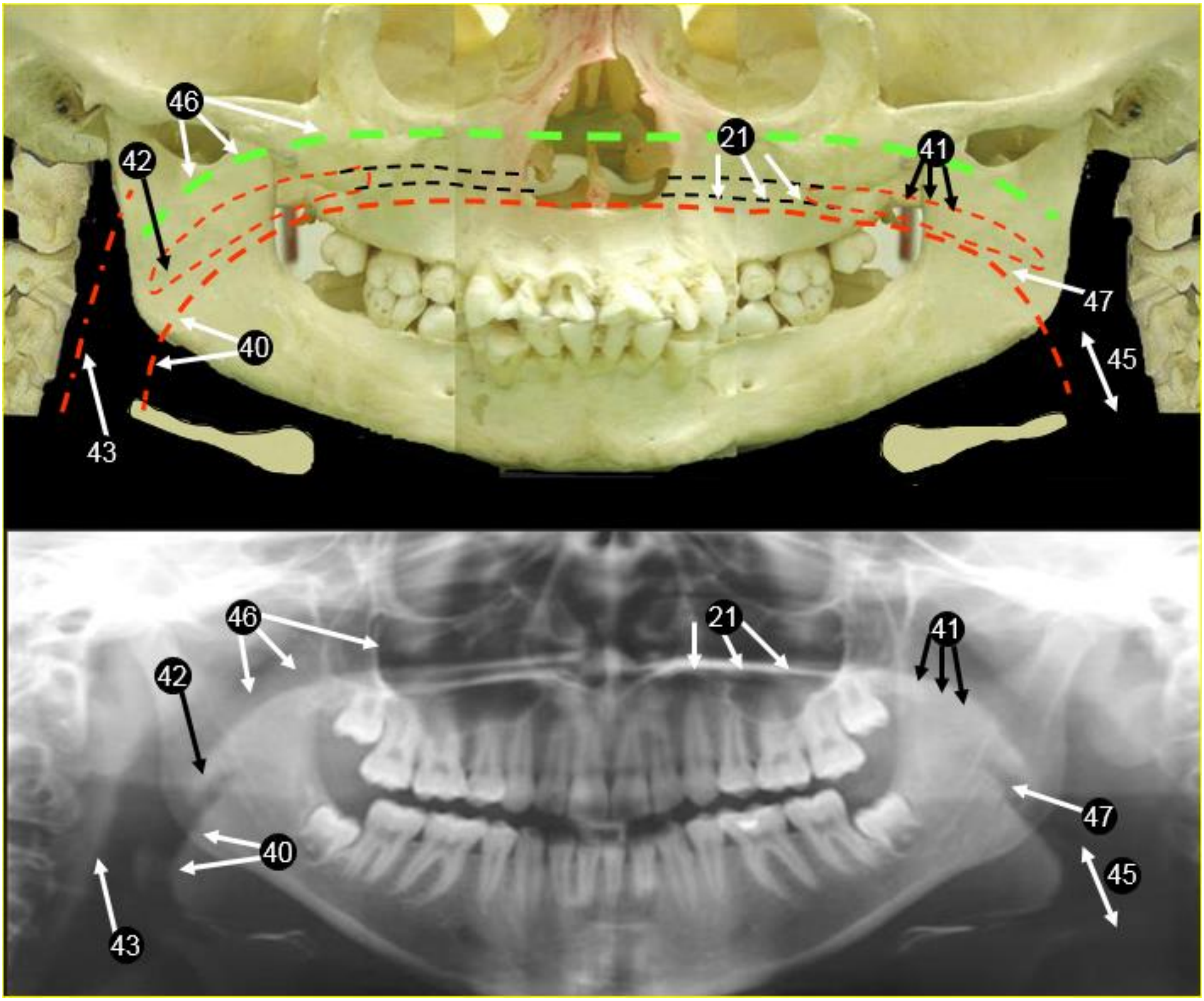


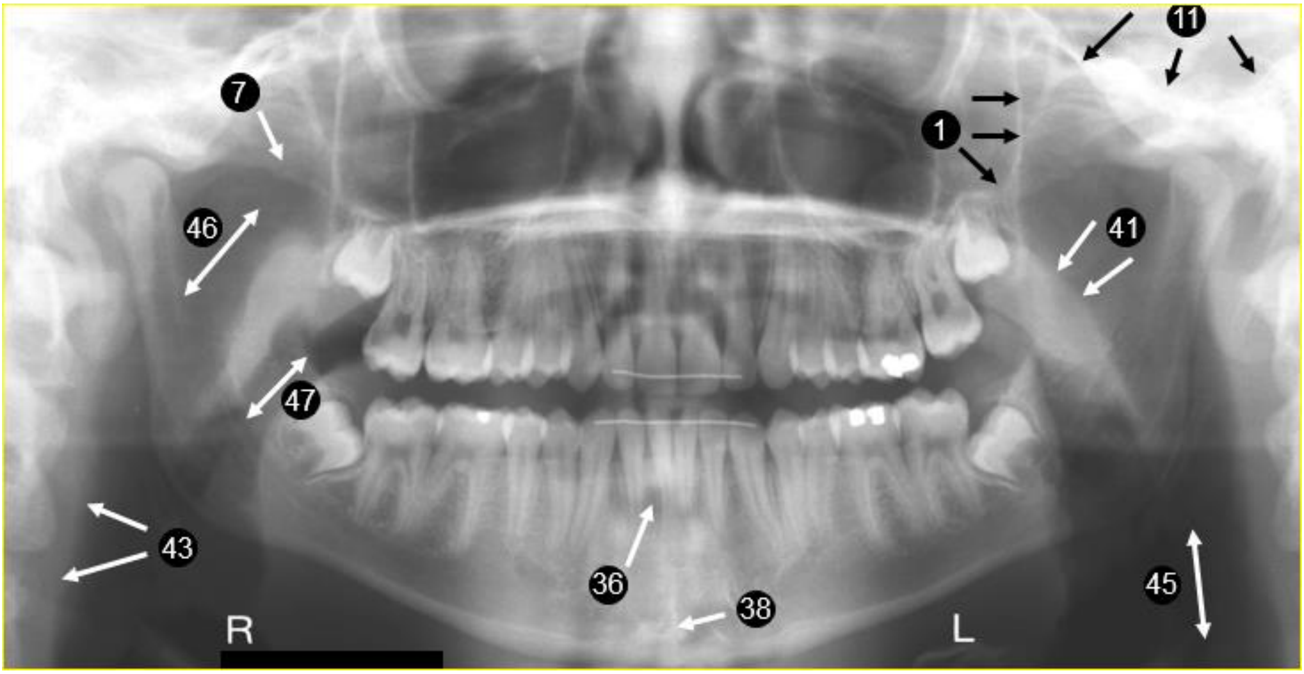
Panoramic Anatomy Key

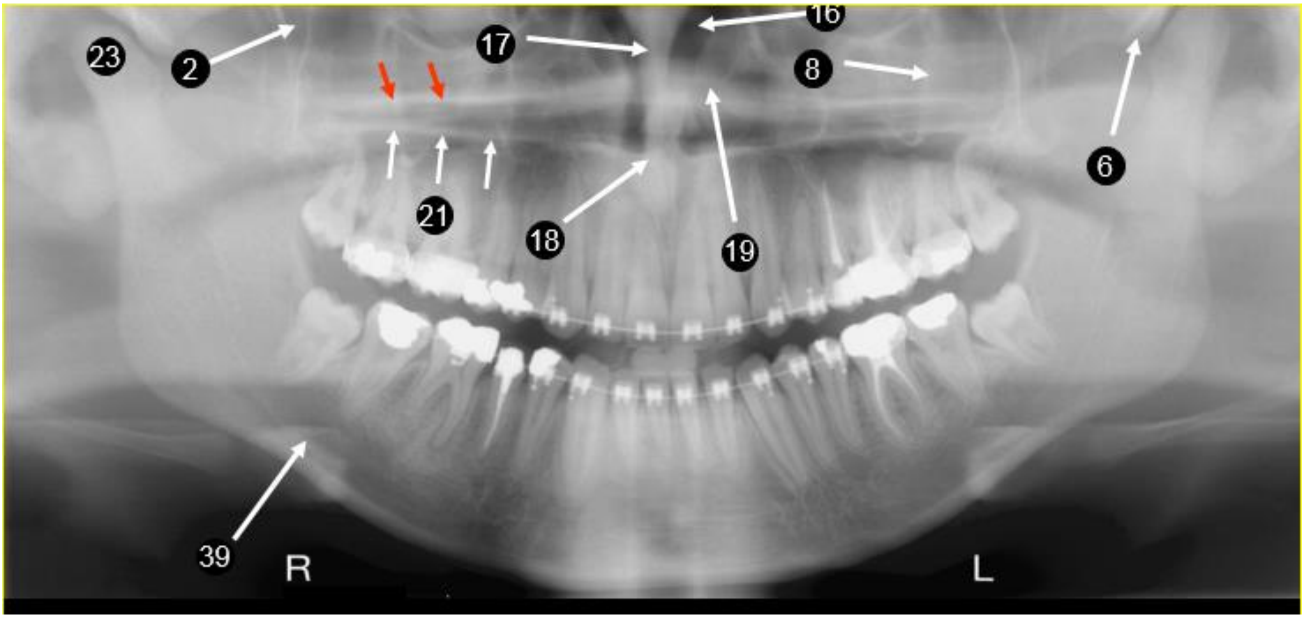
1. maxillary sinus
2. pterygomaxillary fissure
3. pterygoid plates
4. hamulus
5. zygomatic arch
6. articular eminence
7. zygomaticotemporal suture
8. zygomatic process of maxilla
9. external auditory meatus
10. mastoid process
11. middle cranial fossa
12. lateral border of the orbit
13. infraorbital ridge
14. infraorbital foramen
15. infraorbital canal
16. nasal fossa
17. nasal septum
18. anterior nasal spine
19. inferior concha
20. incisive foramen
21. hard palate
22. maxillary tuberosity
23. condyle
24. coronoid process
25. sigmoid notch
26. medial sigmoid depression
27. styloid process
28. cervical vertebrae
29. external oblique ridge
30. mandibular canal
31. mandibular foramen
32. lingula
33. mental foramen
34. submandibular gland fossa
35. internal oblique ridge
36. mental fossa
37. mental ridges
38. genial tubercles
39. hyoid bone
40. tongue
41. soft palate
42. uvula
43. posterior pharyngeal wall
44. ear lobe
45. glossopharyngeal air space
46. nasopharyngeal air space
47. palatoglossal air space


9
12
7
19
5
25
14
17
13
6
22
18
39
28
33
9
12
19
7
17
14
13
5
25
6
22
18
39
28
33

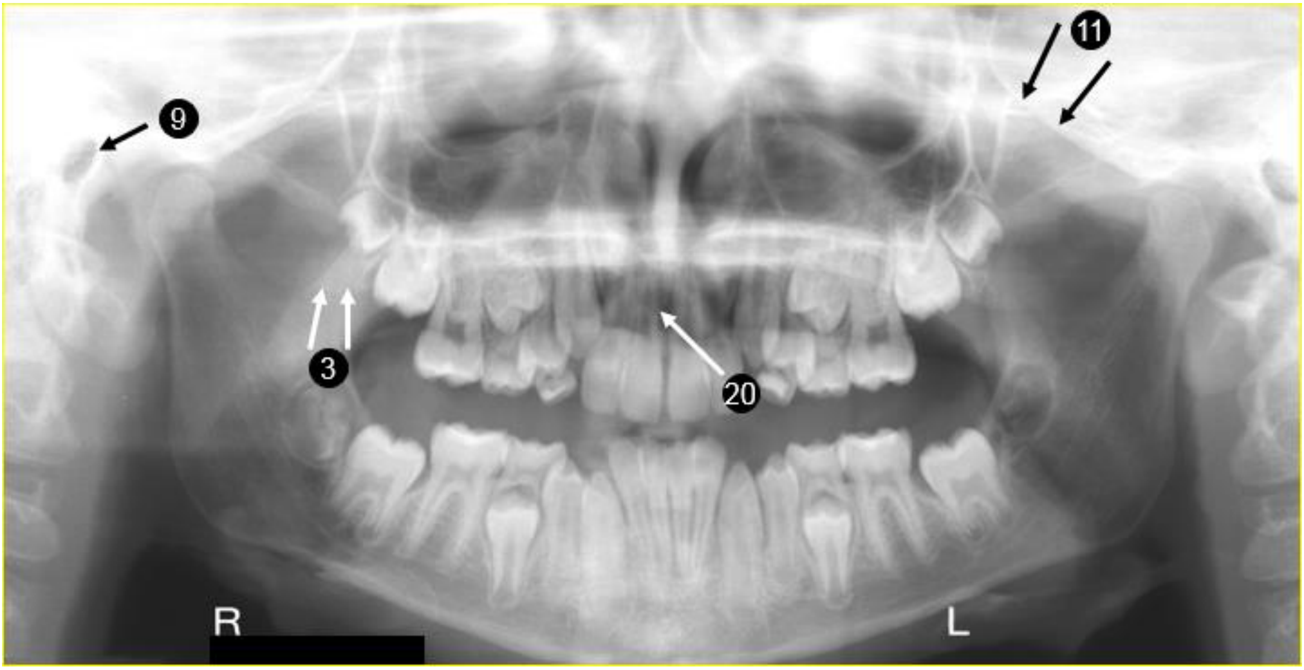

11
15
2
24
26
8
16
1
3
4
32
31
23
44
20
34
30
38

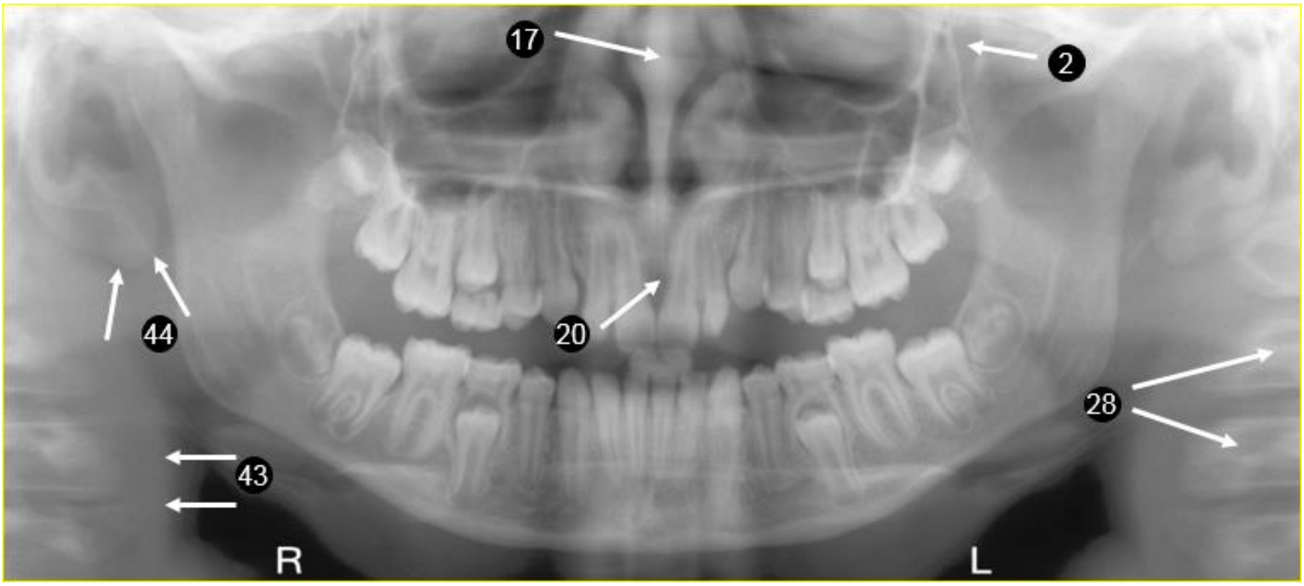

46
21
41
42
47
40
45
43
46
21
41
42
47
40
45
43

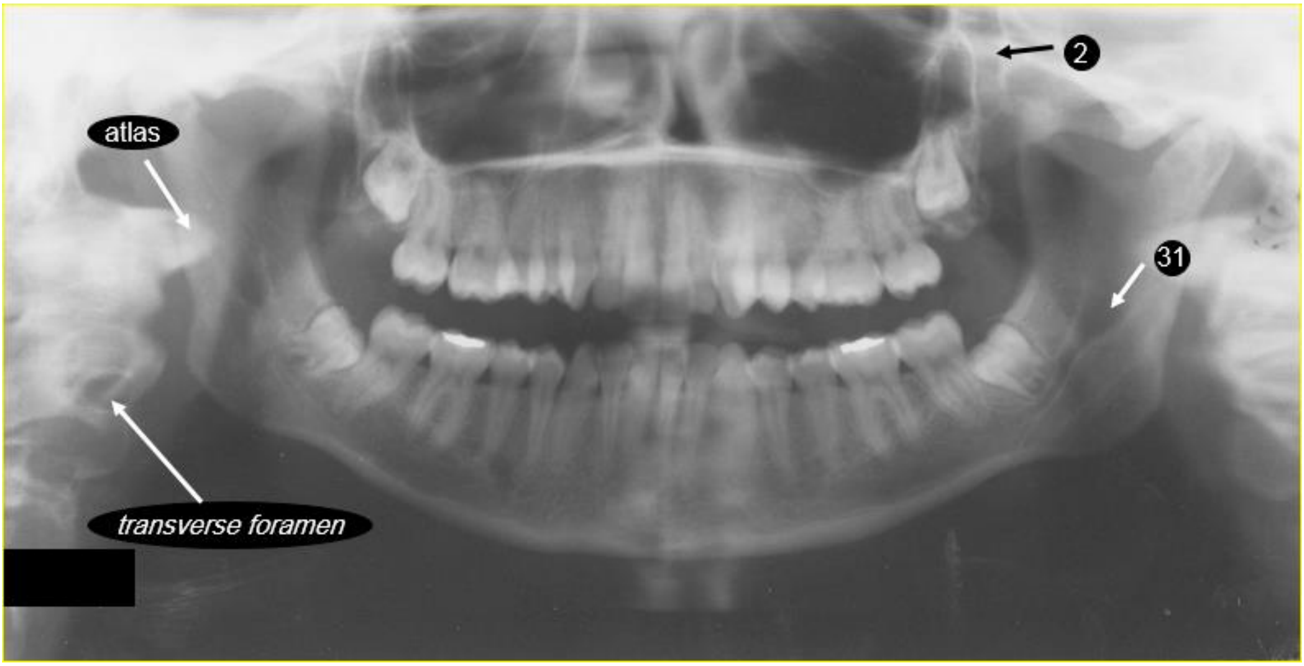

11
7
1
46
41
47
43
36
38
45
R
L

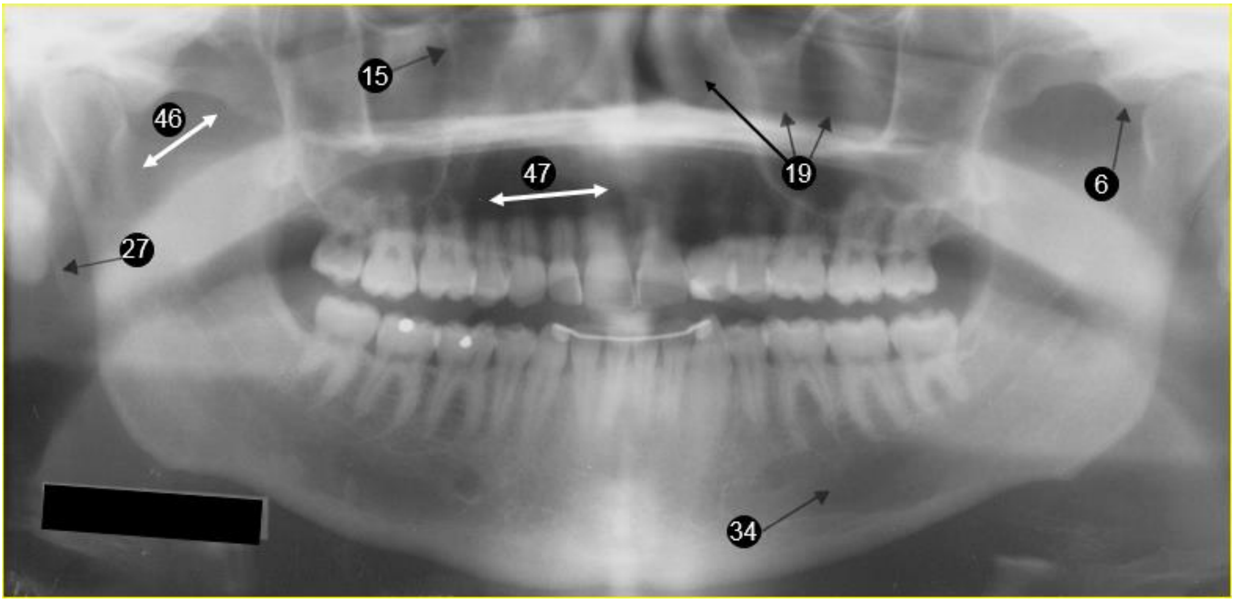


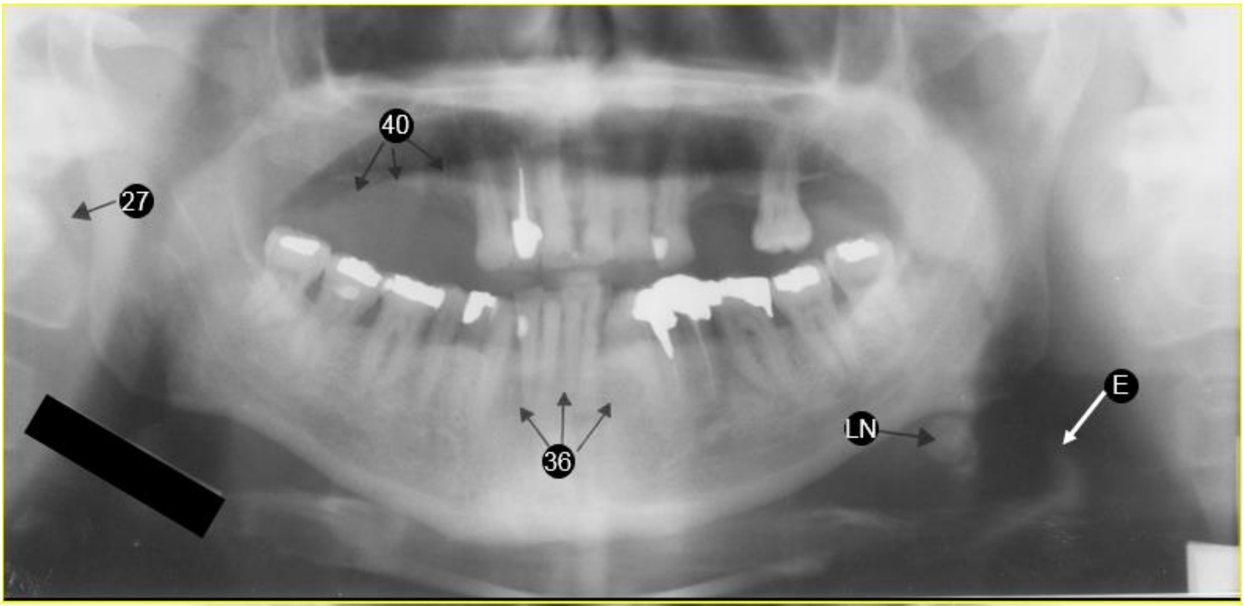
Red arrows point to ghost image of hard palate

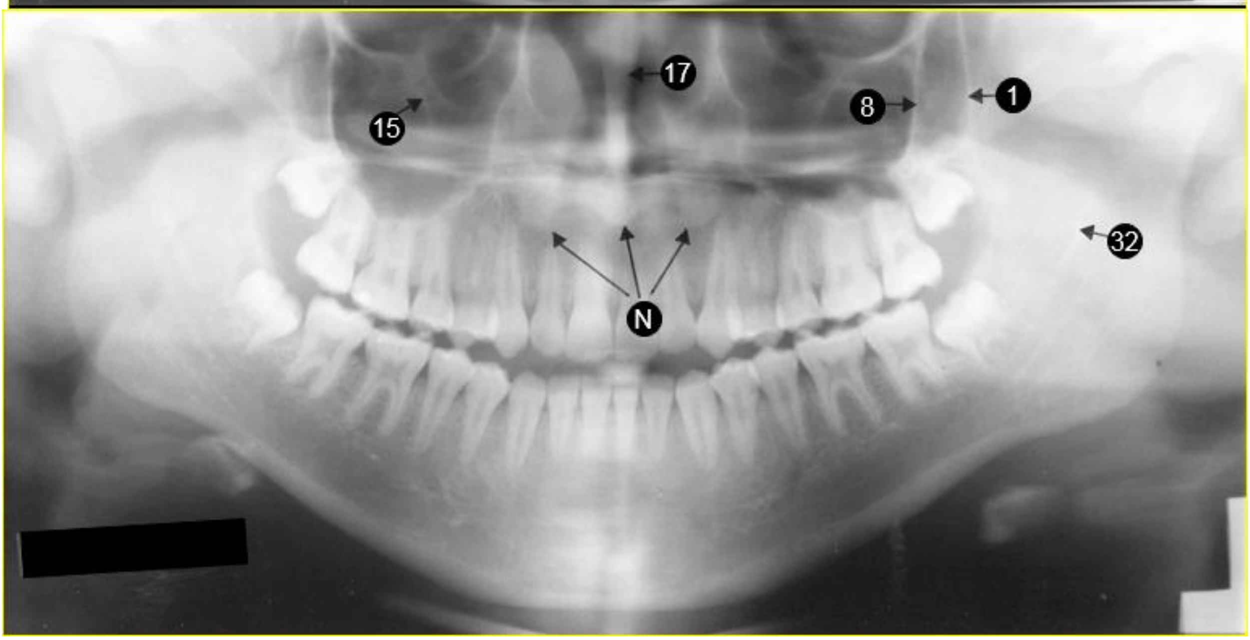



17
2
44
20
28
43
R
L


2
atlas
31
transverse foramen


15
46
47
19
6
27
34


40
27
36
LN
E


17
15
8
1
N
32

REFERENCES:

1. Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The Essential Physics of Medical Imaging: Lippincott Williams & Wilkins; 2011.
2. Richard R. Carlton, Arlene McKenna Adler (2005) Principles of Radiographic Imaging, Delmar.
3. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.

L.13 **Panoramic Radiography**

Panoramic Technique Errors:

By

Mahmood Al-Fahdawi B.S., M.Sc., Ph.D.

Oral Radiology Teacher, Anbar University

Causes and Appearance of Errors in Technique:

A considerable number of radiographs exposed in dentistry are of marginal or nondiagnostic quality. The value of a panoramic radiograph is reduced when it is of poor diagnostic quality, due to various positioning and processing errors. Among the various types of image quality evaluations, clinical imaging evaluation is the most important inspection that enables actual and comprehensive evaluation since it reflects the entire quality-assurance process and it must be performed continuously.

Low-quality radiographs can lead to repetition of radiographs and misinterpretation, which in turn may result in incorrect diagnosis and treatment planning. The repetition of panoramic radiography carries an associated risk of inducing cancer which has been estimated as 0.21 or 1.9 cases/million examinations.

Inaccuracies in patient positioning lead to discrepancies between horizontal and vertical magnification, with consequent distortion of the image. Since a principal objective of the quality assessment program is to ensure the production of good diagnostic quality radiographs, it is vital to monitor image quality on a regular basis. It is recommended that a simple, subjective image quality rating system should be used for dental radiographs.

The diagnostic value of panoramic films is increased considerably if clinicians are aware of their limitations and apply a systematic approach to their interpretation. “The hardest thing to see is what is in front of your eyes.” The value of panoramic radiograph is reduced when they are of poor diagnostic quality. This poor quality usually is not a result of an inherent limitation with the equipment, but rather is a result of errors made by the operators during patient positioning and processing.

It is important for the clinician to be able to understand errors when they occur and how to correct them. The following table lists various errors that can occur with panoramic imaging. It also addresses the radiographic appearance of the errors and solutions for correcting the problem.

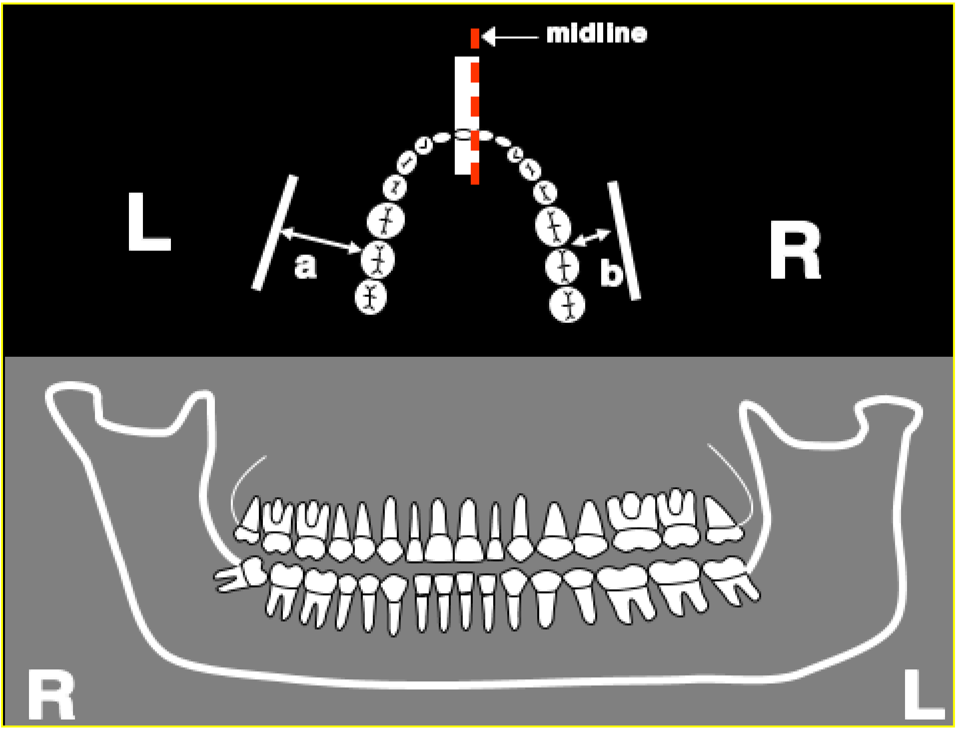
Patient Positioning Errors.

1	Ghost images.	Ghost image resembles real image Projected on opposite side of film and is higher.	Have patient remove all radiodense objects before exposure.
2	Lead apron artifact.	Radiopaque, cone-shaped artifact in center of image.	Use lead apron without thyroid collar.
3	Patient lips not closed.	Dark radiolucent shadow around anterior teeth.	Remind patient to close lips around bite block.
4	Patient chin too high.	Condyles may not be visible Maxillary incisors appear blurred and magnified Reverse smile line (frown).	Keep Frankfort plane parallel with floor.
5	Patient chin too low.	Exaggerated smile line (Joker). Condyles higher on image. Mandibular incisors appear blurred; roots appear short.	Keep Frankfort plane parallel with floor.
6	Patient too far forward (anterior to focal trough).	Anterior teeth are narrowed. Spine is visible on film.	Make sure patient’s teeth are in bite block notches.
7	Patient too far back (posterior to focal trough).	Anterior teeth appear magnified. Ramus isn’t entirely visible.	Make sure patient’s teeth are in bite block notches.

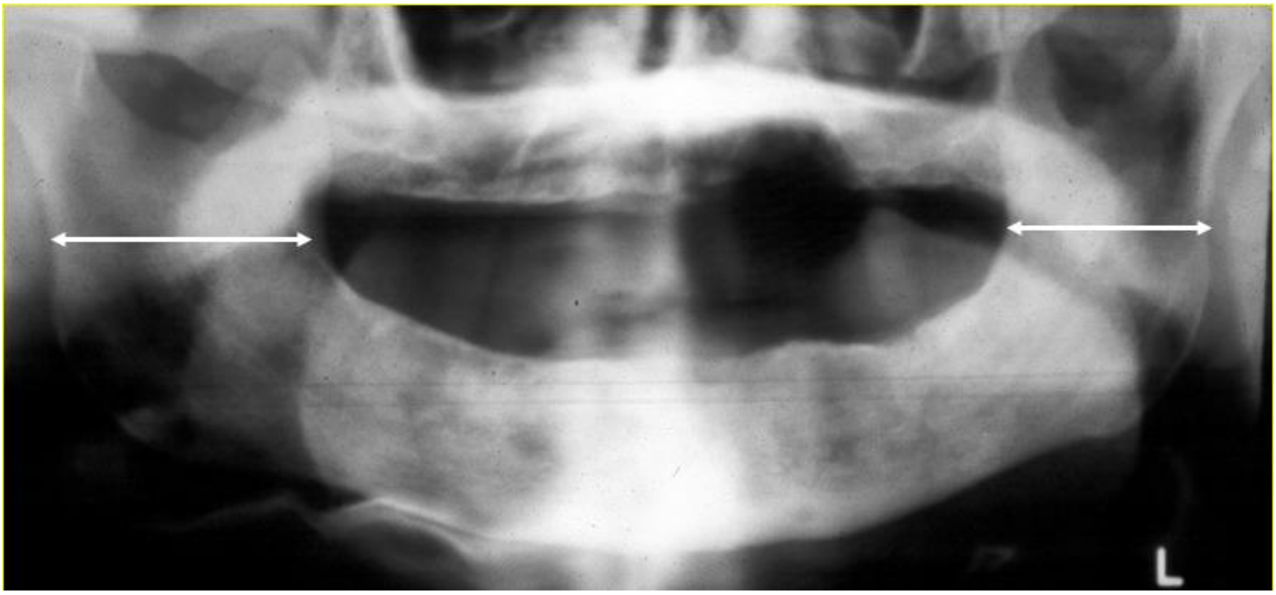
8	Patient head not centered	Ramus and posterior teeth appear unequally magnified. Side farthest from receptor appears magnified. Side closest to receptor appears smaller. Example: Patient turned to right will produce image with magnification on left side and overlapping of contacts.	Keep midsagittal plane perpendicular to floor & ensure indicating light is located at center of patient's nose
9	Patient spine isn't straight	Cervical spine appears as radiopacity in center of image	Have patient stand as tall as possible. Seat patient if necessary.

The most common errors seen when taking panoramic radiographs:

Head Turned:



Turning the head moves the teeth closer to the film on one side (b, above) and farther from the film on the other side (a, above). This results in an enlargement of the images of the teeth and ramus on one side and a reduction in the size of the images on the other side.



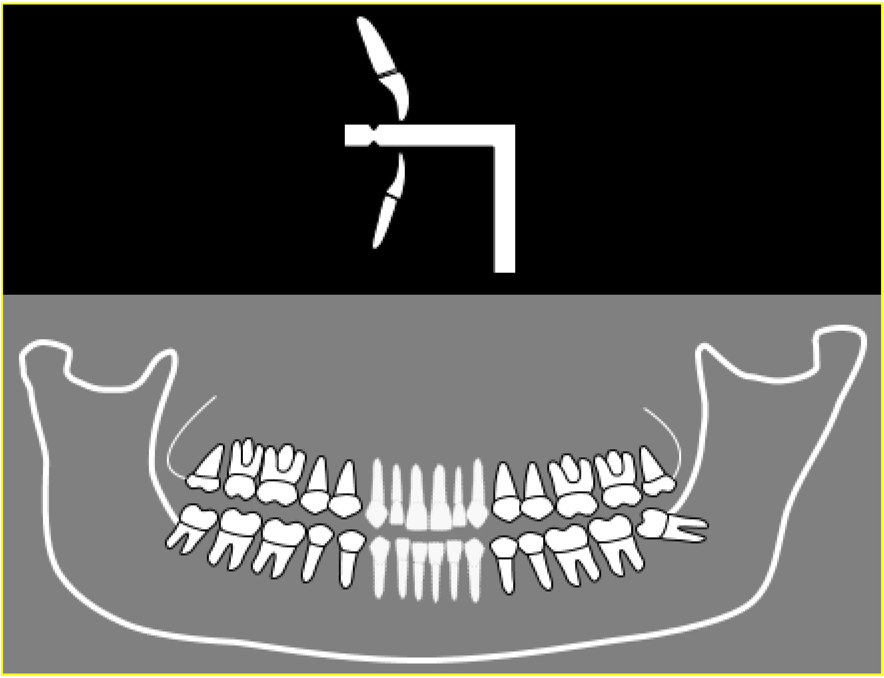
Head turned to the left. The ramus is wider on the right side.

Head turned to the right, moving the teeth closer to the film on that side. The teeth on the left side, being farther from the film, will be magnified more and appear larger.

The head is turned to one side, causing an asymmetry of the condyles, and wider teeth and ramus on one side than the other.

The head is tilted to one side, causing one condyle to appear higher than the other and the inferior border of the mandible is slanting.

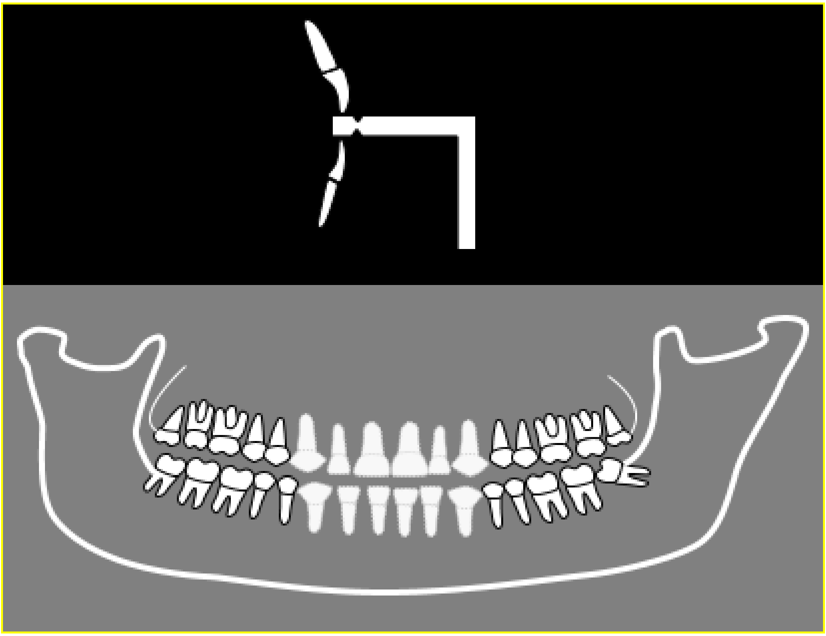
Teeth too anterior:



If the incisors are positioned anterior to the notch in the bitestick, they will end up closer to the film, which passes in front of the patient. This results in a reduction in the width of the images of the front teeth (less magnification) and, since they are now slightly outside the focal trough, the images of the teeth will be blurred.

The central incisors are in front of the bite groove, causing them to appear thin and fuzzy. The cervical spine is in the focal zone, causing it to be superimposed on the mandible.

Teeth too posterior:

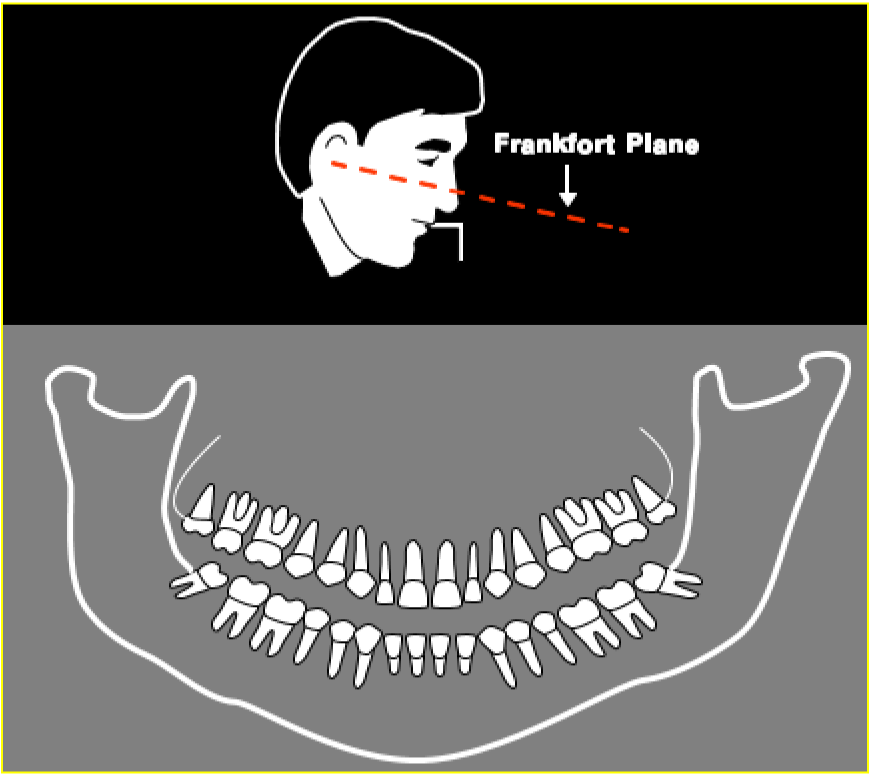


If the incisors are positioned posterior to the notch in the bitestick, they will end up farther from the film, which passes in front of the patient. This results in an increase in the width of the images of the front teeth (more magnification) and, since they are now slightly outside the focal trough, the images of the teeth will be blurred.

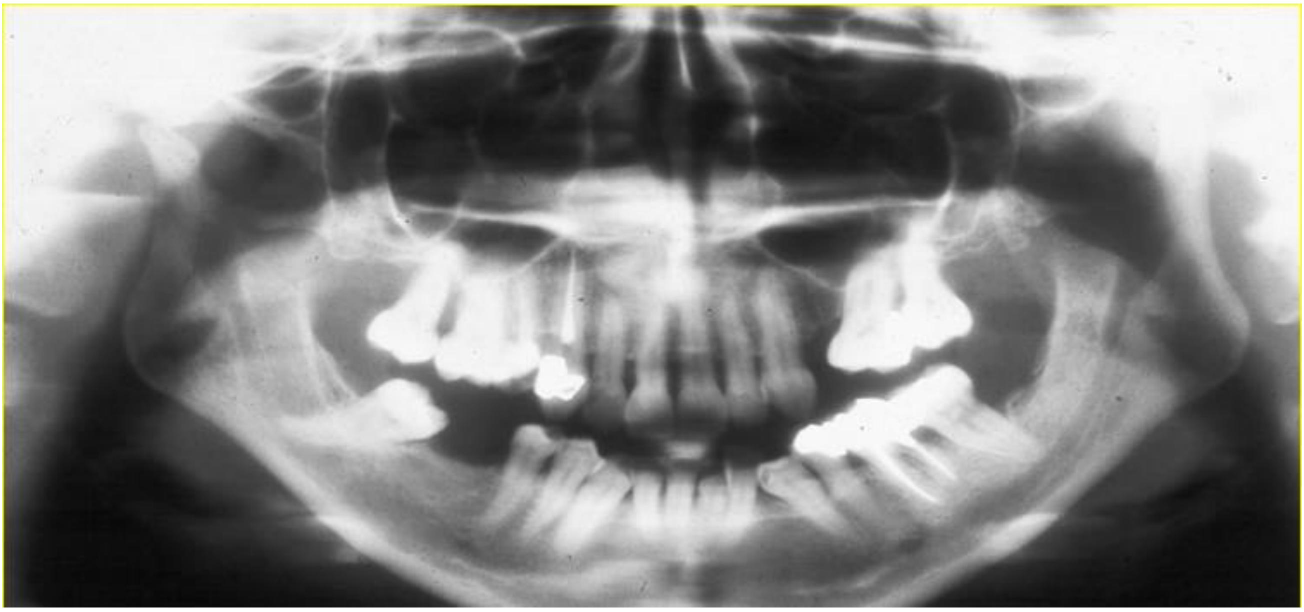
Incisors positioned posterior to notch in bite stick. Incisors wider than normal and blurred.

The anterior teeth are positioned behind the bite groove, causing them to appear wider than normal.

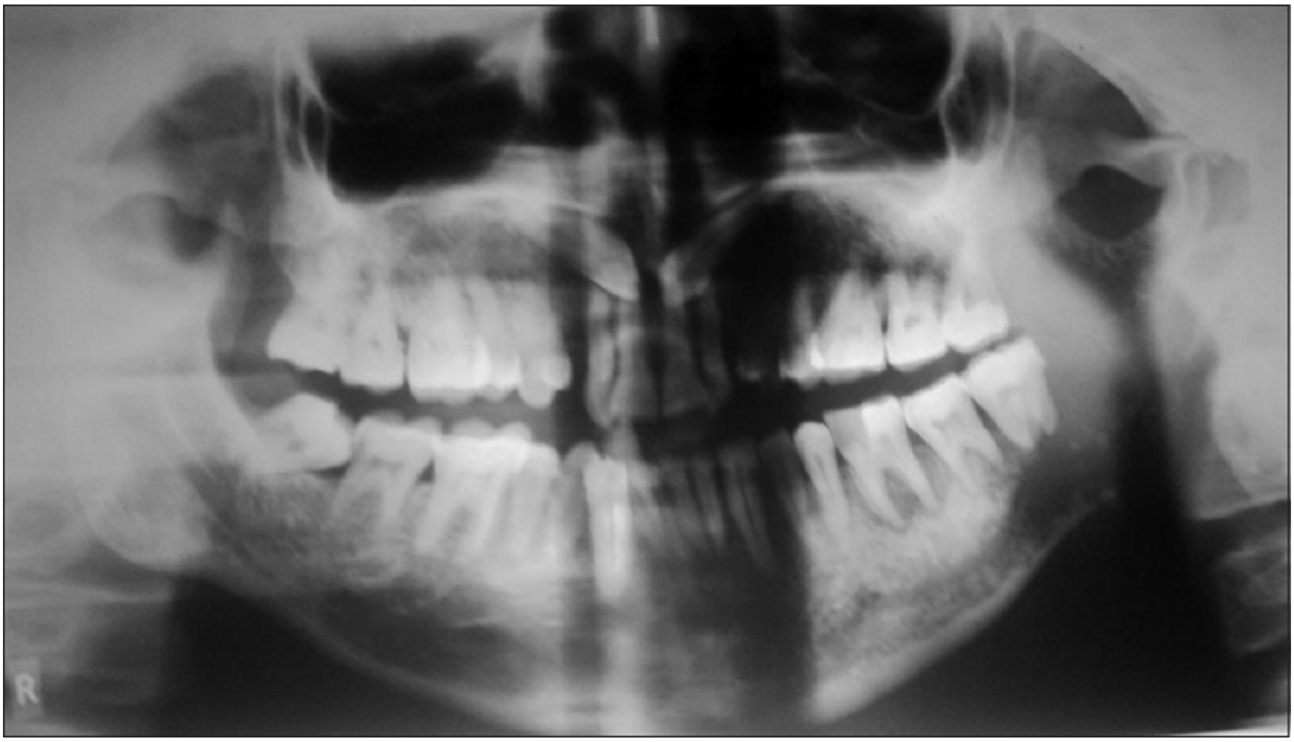
Head tipped down:



If the head is tipped down too much, so that the Frankfort Plane is angled downward, the resulting film will show a V-shaped mandible and shortening of the mandibular incisors.



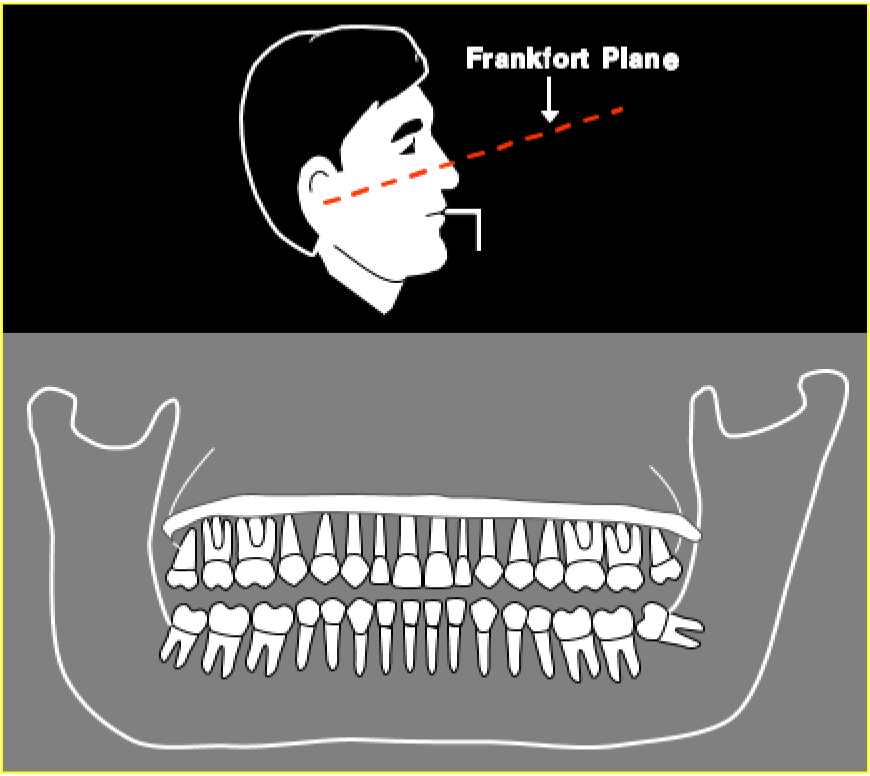
Chin tipped down too much. Roots of mandibular incisors shortened. V-shaped mandible.



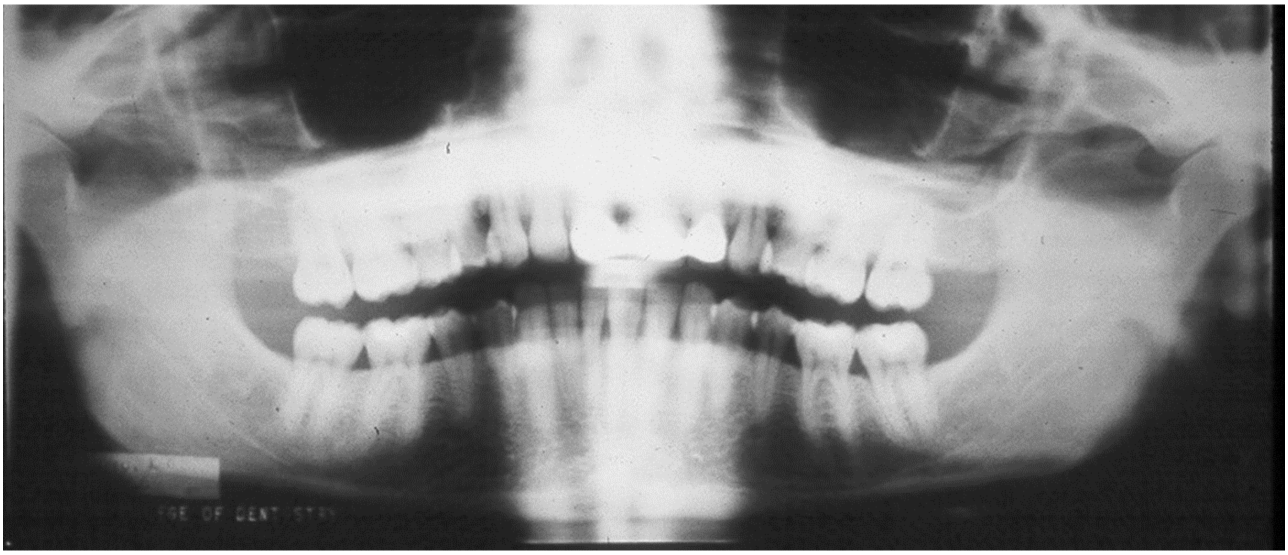
Patient's chin is tilted downward leading to appearance of a “Cheshire cat grin” due to the accentuated Curve of Spee.

The patient's chin is too low. The occlusal plane is “smiling” and the apices of the mandibular incisors are fuzzy.

Head tipped up:

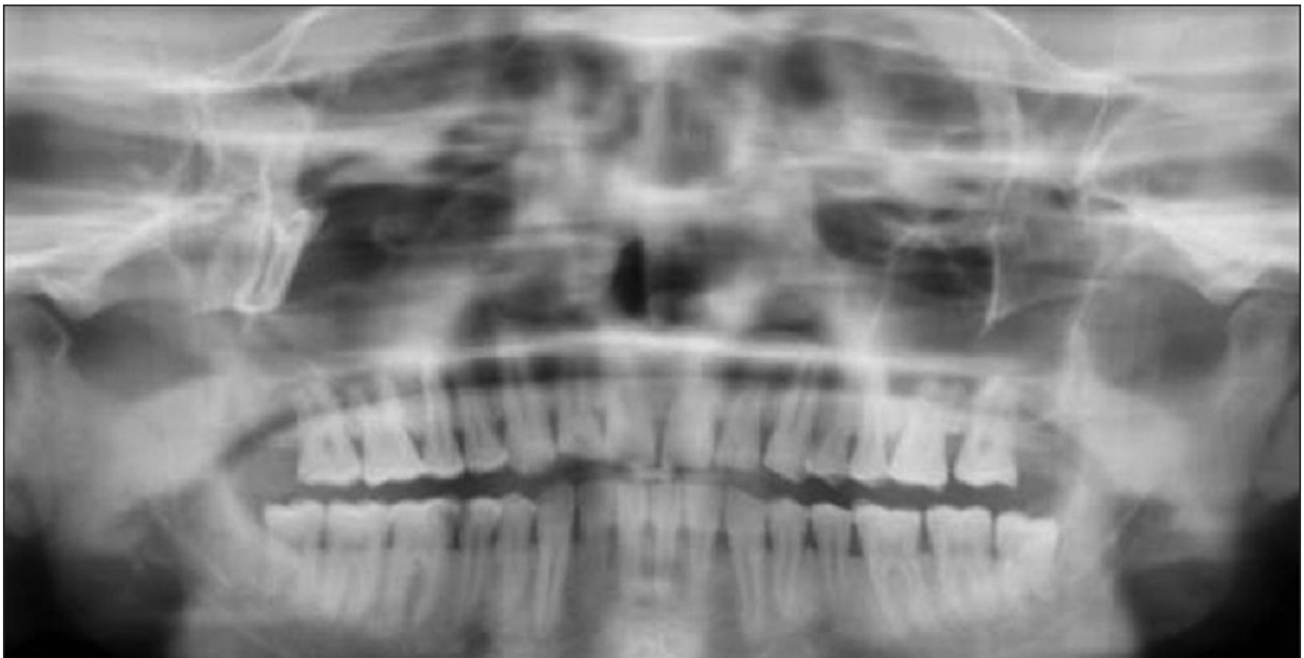


If the head is tipped up too much, so that the Frankfort Plane is angled upward, the resulting film will show a squared-off mandible and the hard palate will be superimposed over the roots of the maxillary teeth. A “reverse smile” may be seen.



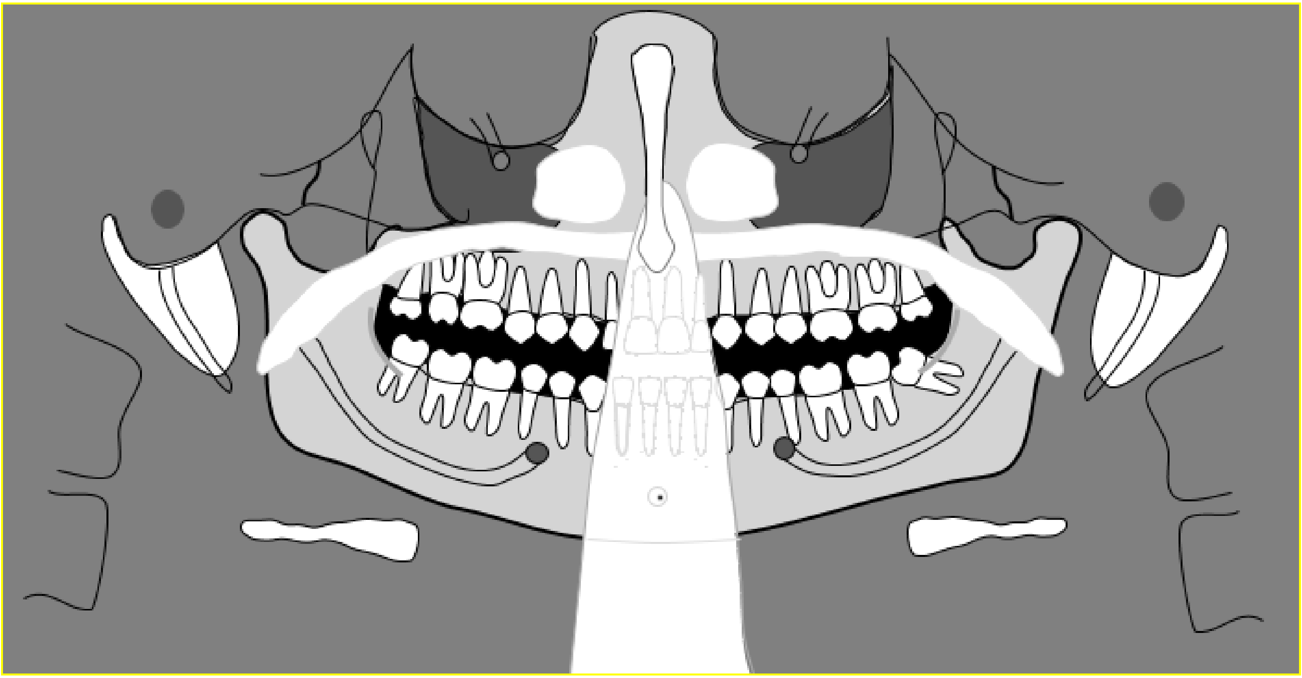
Chin tipped up too much. Hard palate superimposed over roots of maxillary teeth. Squared-off mandible. “Reverse Smile”.

Patient's chin is tilted upward leading to appearance as that of a wide “grimace” due to a flattened Curve of Spee.



The patient's chin is too high, causing a flat occlusal plane, splayed condyles, and loss of sharpness of the maxillary incisors.

Vertebral (spinal) shadow:

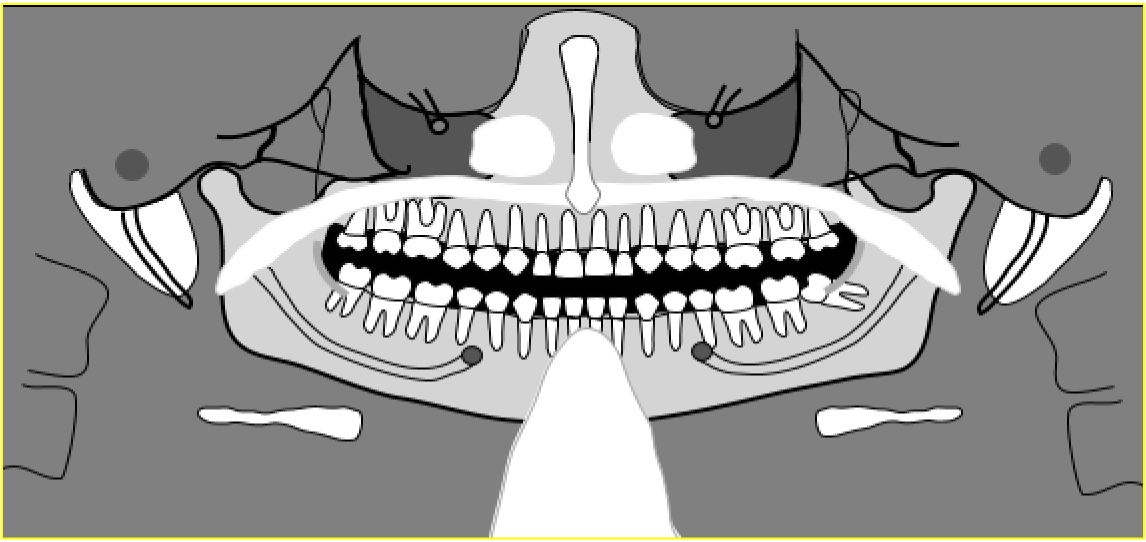


White area in the center of the film represents the shadow of the vertebral column due to patient slouching. Although faint, you will usually be able to see outlines of the teeth and bone in the area.

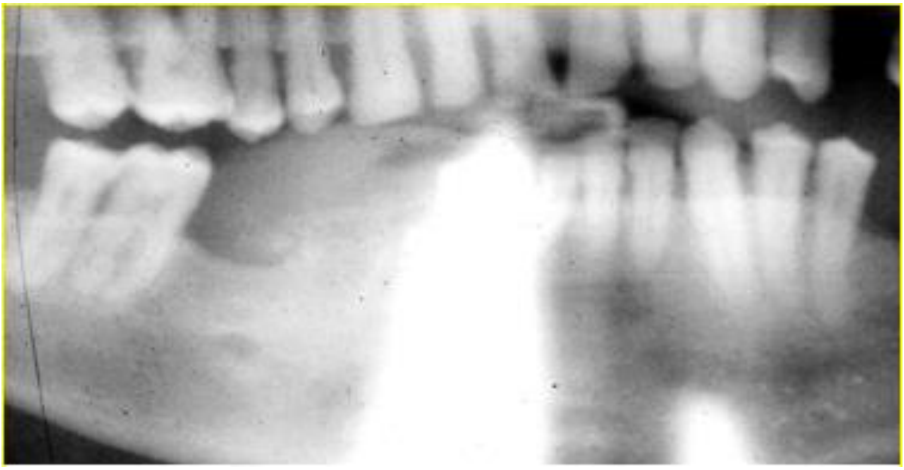
Shadow of the vertebral column due to patient slouching.

The cervical spine is slumped, appearing as a pyramid-shaped opacity, centered at the lower half of the film**.**

Lead Apron shadow:

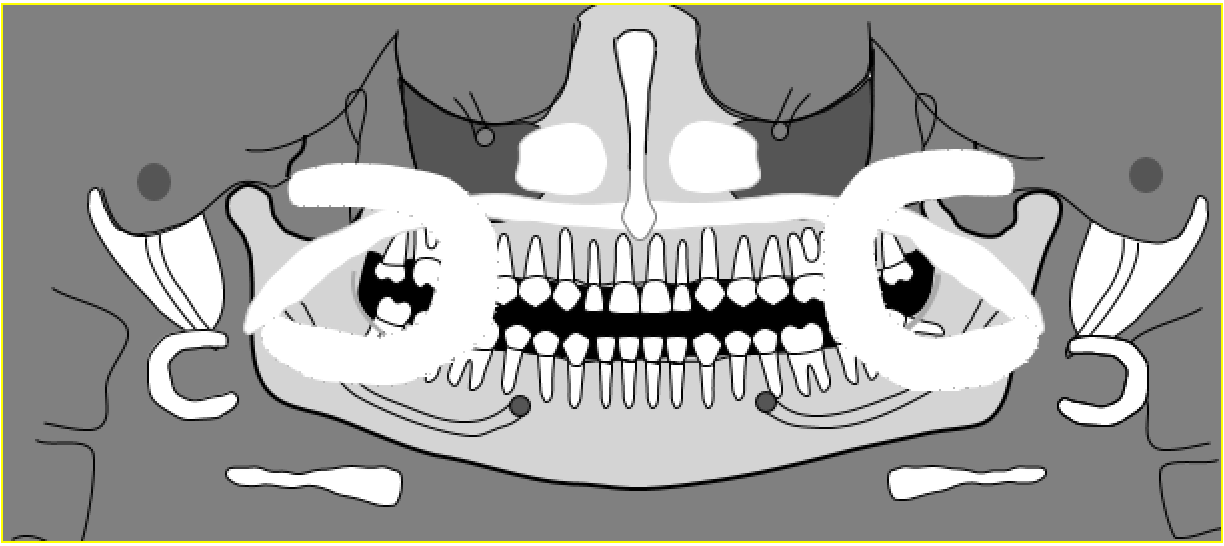


The lead apron should be placed low on the back of the patient’s neck so that it does not block off the x-ray beam as the tubehead passes behind the patient. (A thyroid collar is never used for panoramic films). If the apron blocks the beam, a completely radiopaque shadow is produced on the film overlying a portion of the mandible; no evidence of teeth or bone is seen in this area.



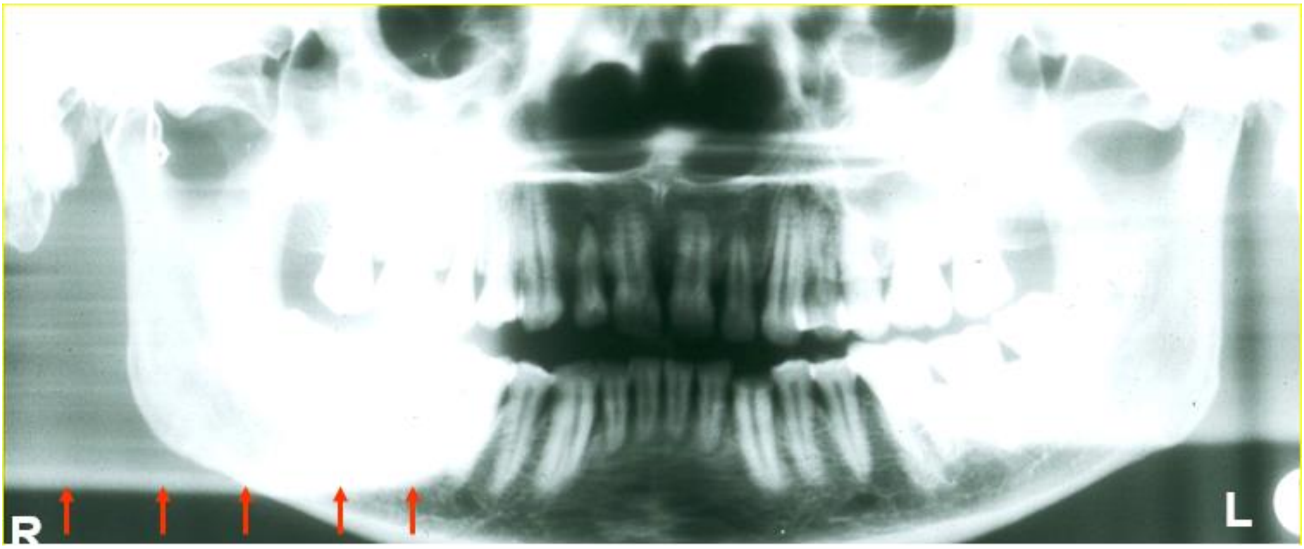
White areas on film represent lead apron being placed too high on back of neck.

Ghost Images:



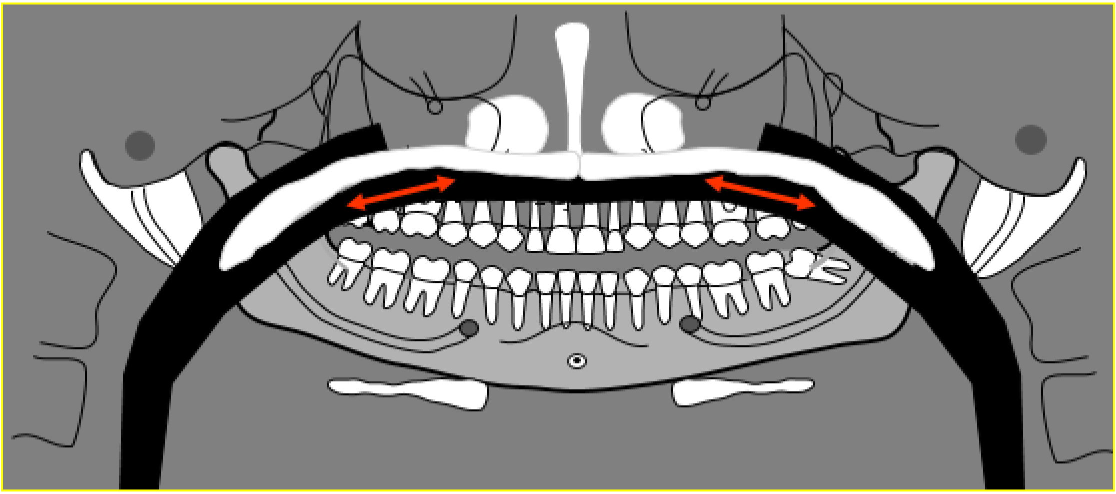
As the x-ray beam passes around the patient, objects such as jewelry or dense bone will produce a real image on the side where the object is located and a "ghost" image on the opposite side. This ghost image will have the same shape and orientation as the real image, but it will be larger and projected higher on the film and will be very blurred.

Ghost images of earrings. The ghost image (see “a-g” above) has the same shape and orientation, but is higher, larger and on the opposite side when compared to the image of the actual object (see “a” above).

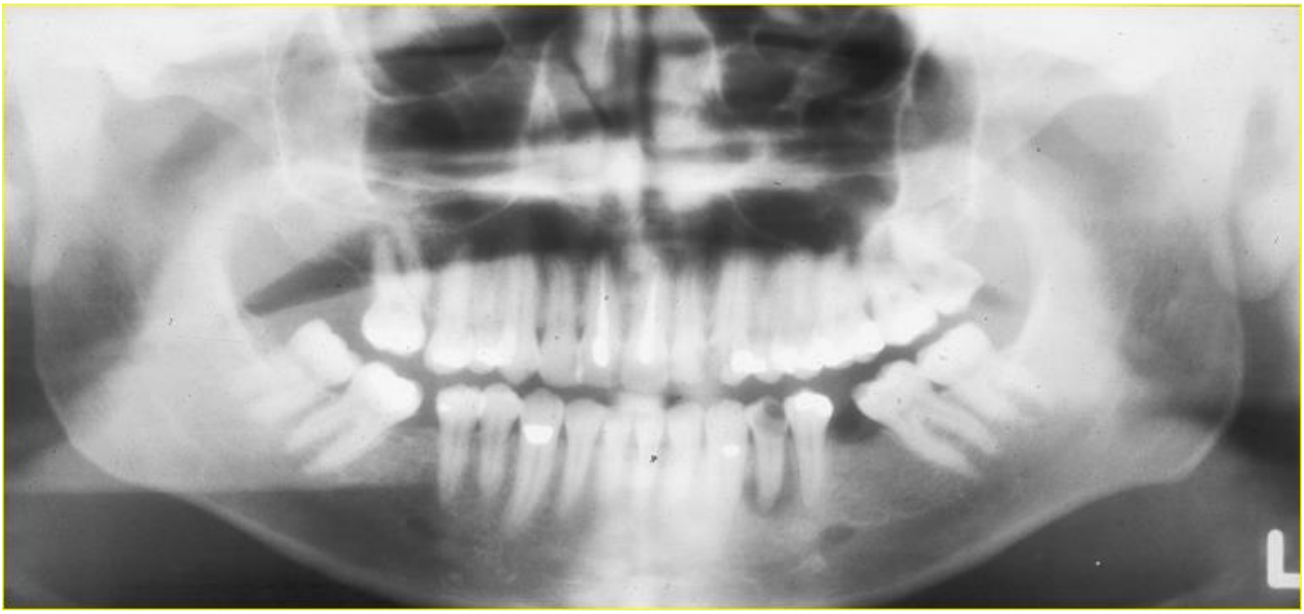


The red arrows above point to the ghost image of the left side of the patient’s mandible.

Palatoglossal Air Space:

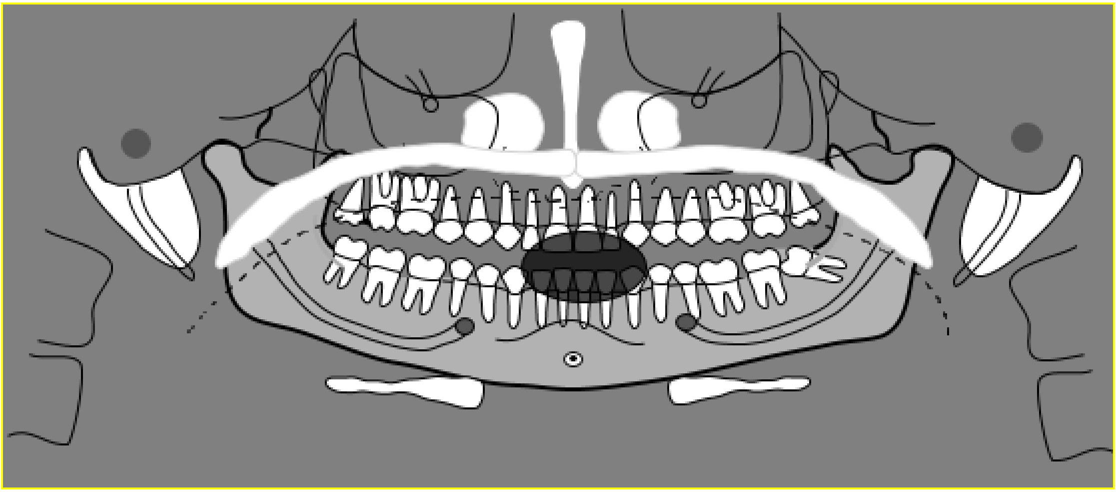


Right before exposing the film, the patient is asked to swallow (to feel the tongue elevate to contact the palate) and to keep the tongue against the palate during the entire exposure. This will help to eliminate the palatoglossal air space (see red arrows above). If this radiolucent band appears on the film, it may mask periapical radiolucencies that might be present.

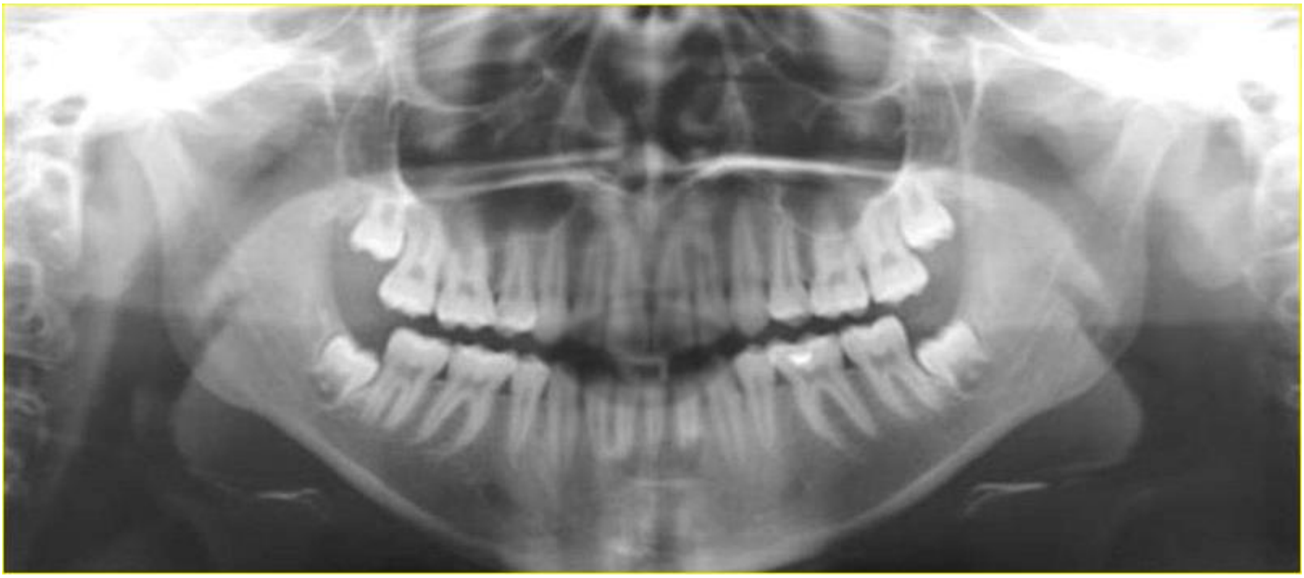


The palatoglossal air space (radiolucent band above roots of maxillary teeth) results from failure to place and maintain the tongue against the palate during exposure.

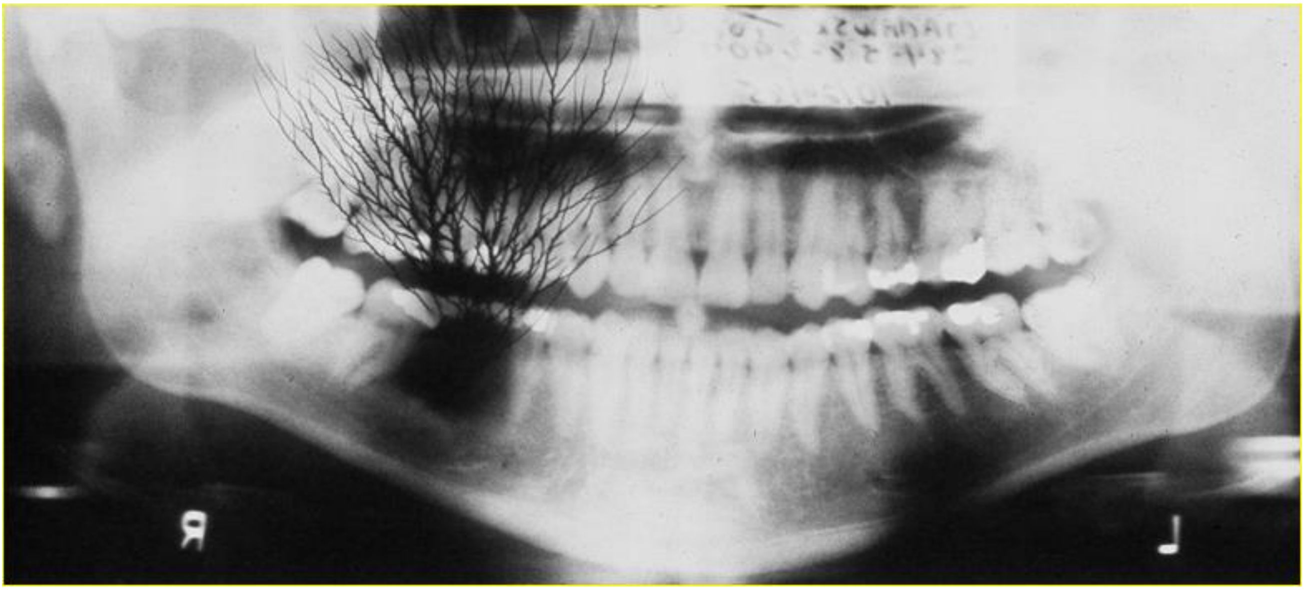
Lip Space:



Right before exposing the film, the patient is asked to close his lips on the bite block. This will help to eliminate the lip space. If this radiolucent shadow appears on the film, it masks the crowns of anterior teeth.

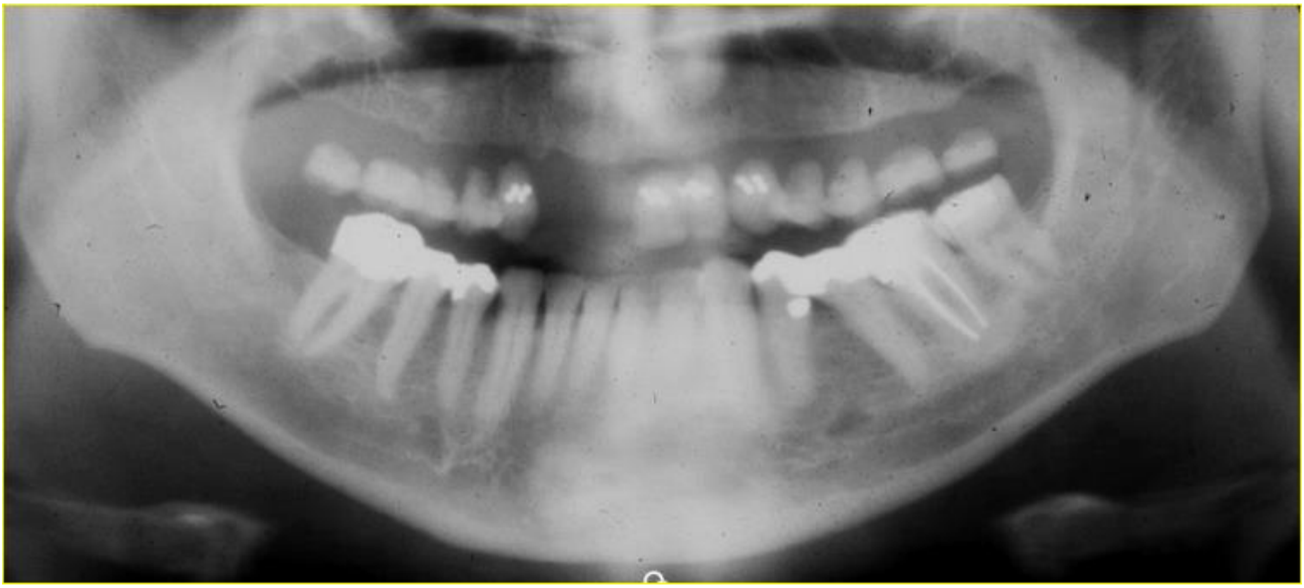


Lip space

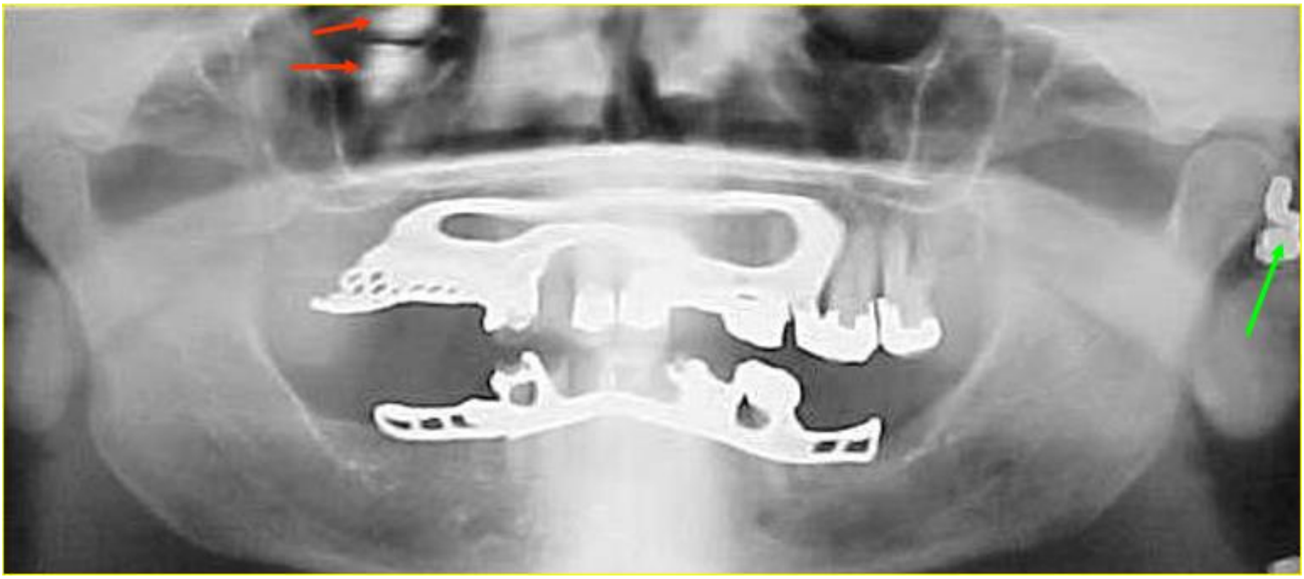


Static electricity caused by friction when removing film from box or cassette too rapidly.

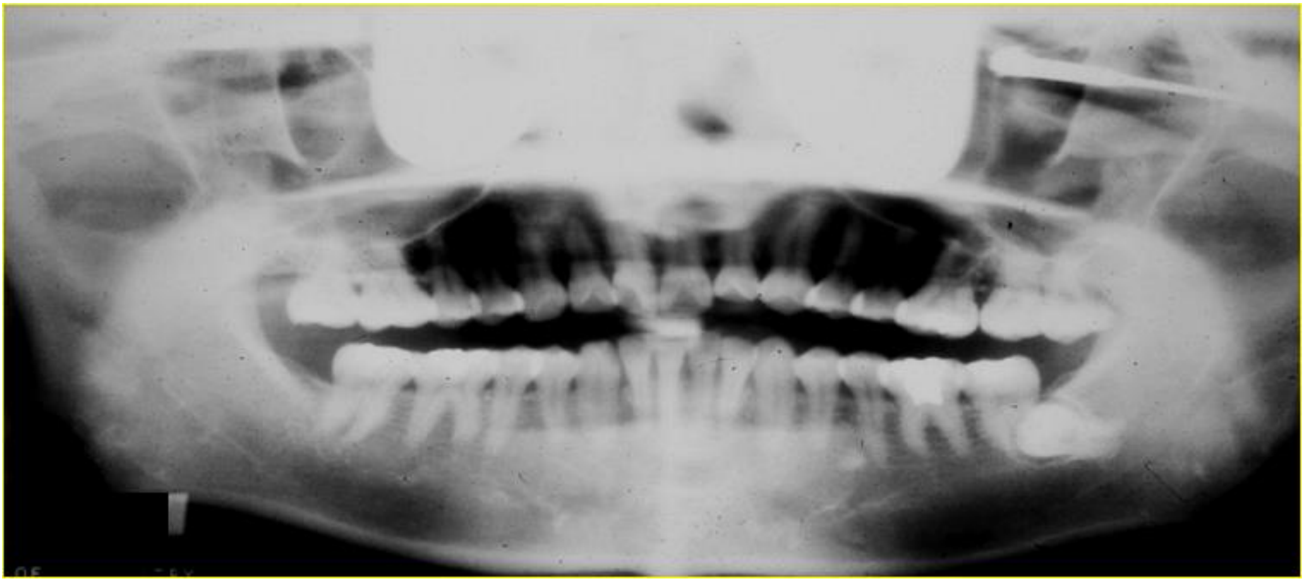
Static electricity caused by friction when removing film from box or cassette too rapidly.



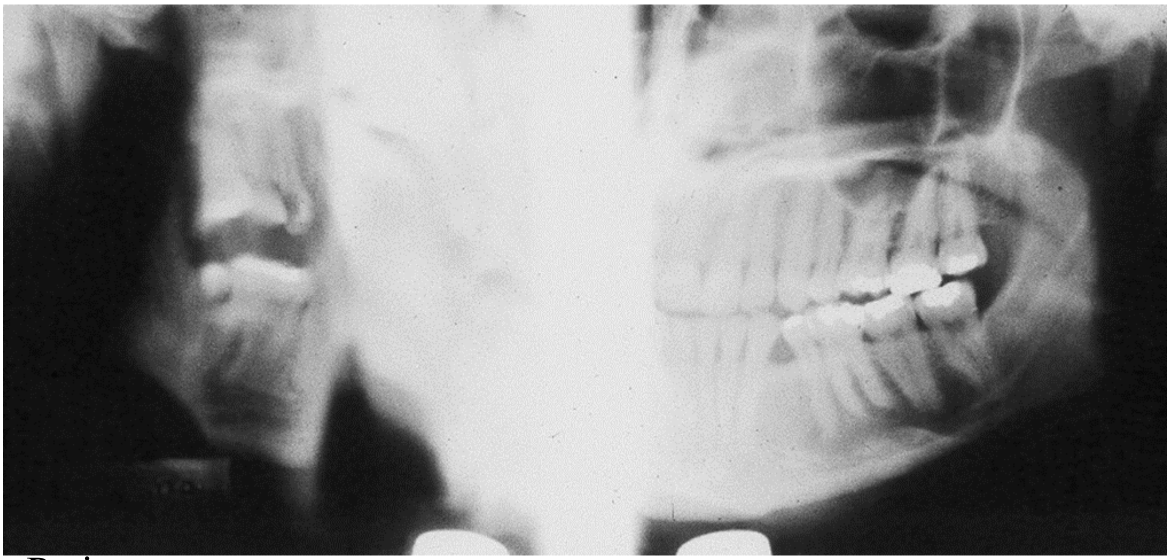
Failure to remove complete upper denture before exposure. This is usually not a problem since the denture acrylic is not dense enough to block the image of the maxillary bone.



Leaving partial dentures in the mouth for a panoramic film will usually obscure important diagnostic information as seen in the above film. Note the hearing aid in the left ear (green arrow) and its ghost image overlying the right orbit (red arrows).



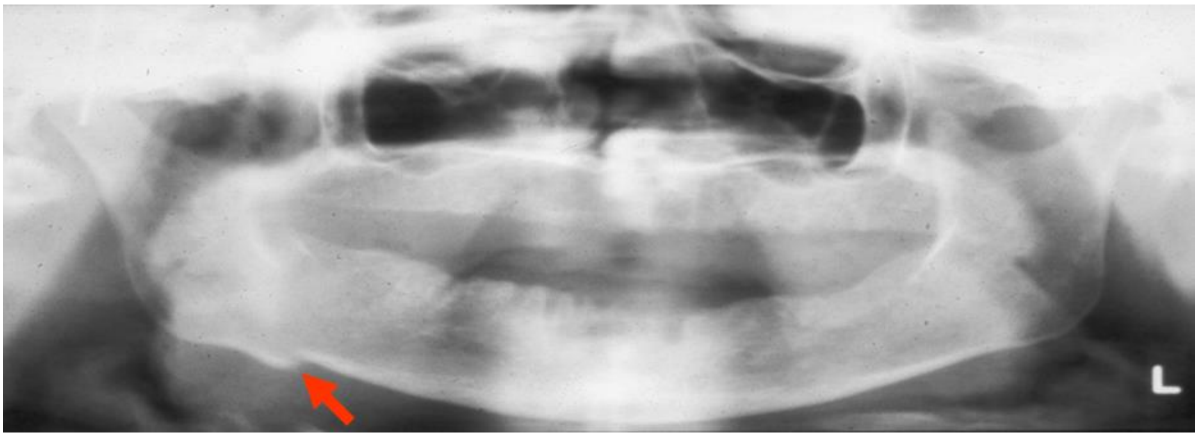
Failure to remove glasses. Also note squared-off mandible and reverse “smile”, indicating chin tipped up too much.



Patient movement.

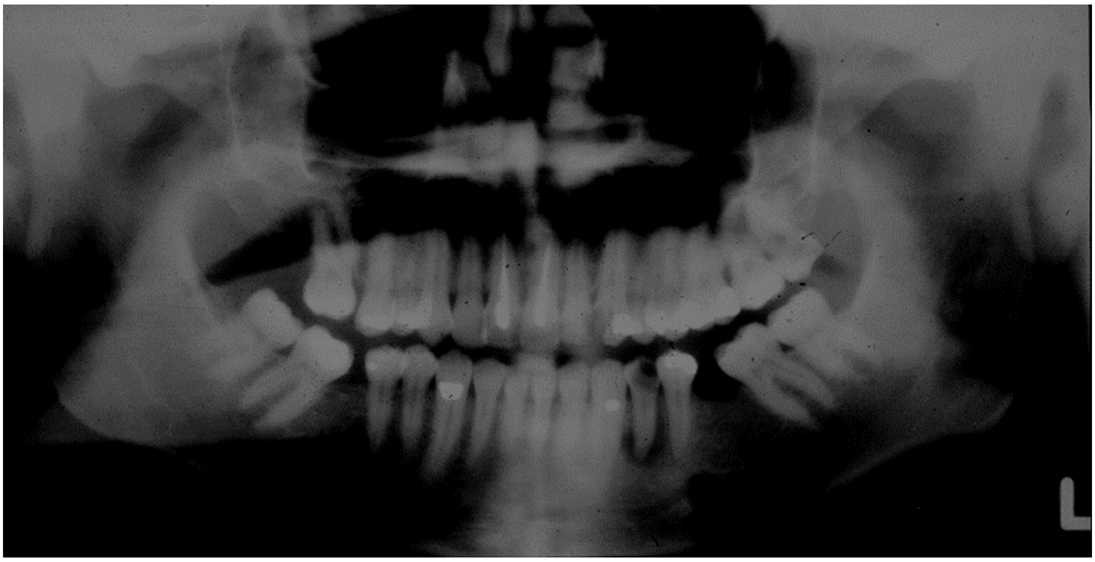
Patient movement

Radiograph shows image distortion due to patient movement during exposure.

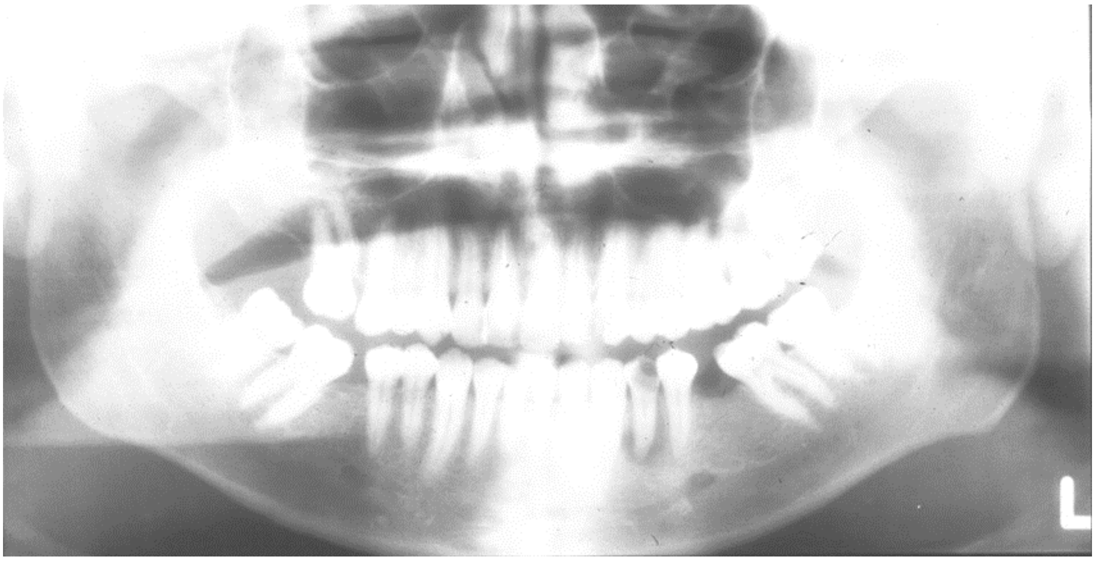


Slight patient movement indicated by notching of mandible at arrow.

Reversed Cassette



Dark image



Light image

Panoramic radiograph shows the patient failure to position the tongue against the palate, leading to a dark shadow over the maxillary teeth between the palate and dorsum of the tongue**.**

Panoramic Technique Errors:

- Patient Preparation Errors
- Ghost images
- Lead apron artifact

– Failure to remove metallic objects

Patient Positioning Errors:

– Positioning of the lips and tongue
– Positioning of the Frankfurt plane
– Positioning of the teeth relative to the focal trough
– Positioning of the midsagittal plane
– Positioning of the spine

Miscellaneous Technique Errors:

– Static Electricity
– Over-exposure or Under-exposure
– Reversed cassette

REFERENCES:

1. Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The Essential Physics of Medical Imaging: Lippincott Williams & Wilkins; 2011.
2. Richard R. Carlton, Arlene McKenna Adler (2005) Principles of Radiographic Imaging, Delmar.
3. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.

L.7

Dental X-ray film processing

By

Mahmood Al-Fahdawi B.S., M.Sc., Ph.D.

Oral Radiology Teacher, Anbar University

Introduction:

Film processing refers to a series of steps that produce a visible permanent image on a dental radiograph.

Aims of Processing:

1. To convert the latent image (invisible) on the film into a visible image.
2. To preserve the visible image so that it is permanent and does not disappear from the dental radiograph.

Processing Techniques:

1. Manual processing (Sight or visual method and time-temp method).
2. Rapid processing chemicals.
3. Injectable intra-oral films.
4. Self-processing intra-oral films.
5. Automatic film processing.
6. Filmless radiographic technique (direct digital radiography).

Manual Processing:

1. Replenish solutions.
2. Check solutions levels.
3. Stir solutions.
4. Check temperature.
5. Mount films on hangers.
6. Set the timer.
7. Develop (5 minutes at 68 F, agitate for 5 seconds).
8. Rinse for 30 seconds (agitate continuously).
9. Fix for 4 minutes (agitate intermittently, 5 sec/30 secs).
10. Wash for 10 minutes in running water.
11. Dry.

Manual Film Processing Steps:

- Consists of following five steps:
  - Development
  - Rinsing
  - Fixing
  - Washing
  - Drying

Development:

A chemical solution developer is used in the development process. Purpose of Developer:

1. The exposed, energized silver halide crystals chemically converted into black metallic silver.
2. Softens the film emulsion during the process.

The developer reduces all the silver ions in the exposed crystals to grains of metallic silver. This process must be restricted to the exposed crystals only.

The metallic silver at the latent image site acts as a bridge by which electrons from the developing solution reach silver ions in the crystal and convert them to metallic silver.

Individual crystals are developed completely or not at all. Variations in density on the processed radiograph are the result of different ratios of developed and undeveloped crystals.

The crystals that do not have exposure centers are not affected by the developer if films are in the developer for the correct amount of time and the temperature of the developer is correct.

However, if the films are left in the developer too long, or the temperature is too high, the developer will start to act on the crystals that were not exposed by x-rays (no exposure centers) and these crystals will also be converted to black metallic silver. This results in the film being darker than ideal (Chemical fog).

Rinsing:

Films should be rinsed in water for 30 seconds with continuous gentle agitation is necessary after developing before they are placed in the fixer:

1. It dilutes the developer and slowing the development process.

2. It also removes the alkaline activators to prevent neutralization and contamination of the acidic fixer.

Not used with automatic processing.

Fixing:

A chemical solution fixer is used in the fixing process.

Purpose of Fixer:

1. Remove the unexposed, unenergized silver halide crystals from the film emulsion.
2. Hardens the film emulsion during the process.

Washing:

Necessary to thoroughly remove all the excess chemicals from the emulsion. The film is washed in a sufficient flow of water from 15 to 20 minutes.

To remove all Thiosulfate ions and Silver Thiosulfate complexes. Any Silver compounds or Thiosulfate that remains because of improper washing causes yellowish brown stains which are most apparent in the radiopaque areas. This discoloration results from the Thiosulfate reacting with Silver to form brown Silver Sulphide.

Drying:

After the films have been washed, surface moisture is removed by gently shaking excess water from the films and hanger. The films are dried in circulating moderately warm air

If the films are dried rapidly with small drops of water clinging to their surface, the areas under the drops dry more slowly than the surrounding areas. This uneven drying causes distortion of the gelatin, leaving a drying artifact.

Excessive heat must be avoided as it may damage the emulsion. Drying air should be filtered and free of dust and lint, since these particles may stick to the wet film as it dries and produce undesirable artifacts. Drying can be done using an electric fan or cabinet driers.

Should be air dried at room temperature in a dust free area. Must be completely dried before they can be handled for mounting and viewing.

Processing Room Requirements:

Darkroom:

- At least 4 x 5 feet.
- Light proof.
- Well ventilated.
- Safe lighting.
- White illumination.

A well planned dark room makes the processing easier, which should be of at least 4 × 5 feet (1.2 × 1.5 m).

Characteristics of darkroom:

1. Convenient location and adequate size.
2. Ample working space with adequate storage.
3. Lighting.
4. Temperature and humidity controlled.
5. Darkroom plumbing.
6. Miscellaneous.

Location:

Darkroom should be located near the area where the x-ray units are installed. Darkroom size is determined by the following factors:

1. Volume of radiographs processed and number of persons using the room.
2. Working Space: Adequate counter area where films can be unwrapped. A clean, organized work area is essential which should be free of processing chemicals, water, dust, and debris.
3. Storage Space: Adequate space for storage for chemical processing solutions, film cassettes etc.
4. Lighting: The room must be completely dark and must exclude all visible light. Any leaks of white light in the darkroom causes film fog.

Two types of lighting are essential in darkroom. Room lighting (white illumination) and Safe lighting. Room lighting: Incandescent room lighting is required to perform task such as cleaning, stocking materials and mixing chemicals, this is not associated with the act of processing films. Safe lighting Special kind of lighting of relatively long wavelength and low intensity illumination that does not rapidly affect open film but permits one to see well enough to work in the area. To minimize the fogging effect of prolonged exposure, the safe light should have a 15 W bulb and a safe light filter (red GBX-2 filter). It should be mounted at least 4 feet (1.2 meters) above the surface where films are handled.

Temperature and Humidity: Should be controlled to prevent film damage. Room temp of 70 degree F is recommended; if exceeds 90 degree film fog results. Humidity level of between 50 and 70 percent should be maintained; when too high, film emulsion does not dry; when too low, static electricity becomes a problem and causes film artifacts.

Darkroom Plumbing: Must include both hot and cold running water along with mixing valves to adjust the water temperature in the processing tanks with utility sink. **Miscellaneous Requirements:** i) Wastebasket for disposal of all film wrappings. ii) X-ray view box used to examine radiographs.

Equipment Requirements: Manual Processing tanks, Timer, Thermometer, Film hangers, and miscellaneous equipment.

Manual Processing Tank: Has 2 insert tanks and 1 master tank. Constructed of stainless steel -Does not react with processing solutions and easy to clean. Practical size for a master tank in dental office is about 20 × 25 cm.

Insert Tanks: 2 removable 1-gallon (3.8 L) insert tanks hold the developer and fixer solutions, placed in master tank. Developer solution is placed on the left and fixer solution placed on right in the master tank. Water in master tank separates the two insert tanks. **Master Tank:** Filled with circulating water. An overflow pipe is used to control the water level in the master tank.

Timer: A timer is use to signal the radiographer that the films must be removed from the current processing solution. Development time depends on the temperature of the developer solution.

Thermometer: Use to determine the temperature of developer solution; optimum temp is 68 degree F, below 60 degree F chemical works too slowly, results in under development; above 80 F chemical works too rapidly, will cause film fog. Floating thermometer or one that is clipped to the side of the developer tank may be used. Temperature of developer sol, determine the development time.

Film Hangers: Also known as processing hangers. Device equipped with clips used to hold films during processing. Made up of stainless steel. Available in various sizes and can hold up to 20 intraoral films. **Miscellaneous Equipments:** i) Stirring rods-made up of plastic or glass use to stir the developer and fixer solutions, and equalizes the temperature of the solutions. ii) Plastic apron-use to protect clothing during the processing of films and mixing of chemicals.

Manual Processing Procedure:

The film is placed in the developer for a specific time (5 min. at 68 degrees) with the lid in place to keep out light. The developer turns the silver halide crystals into black metallic silver.

After the proper time in the developer, the lid is removed and the film hanger is placed in the water bath to rinse off the developer (agitate for 30 seconds). The films are then placed in the fixing solution. (Agitate for 5 seconds every 30 seconds).

After the proper time in the fixer (4 minutes), the film hanger is placed in the water bath (10 minutes) to wash off any remaining solutions. The films are then hung to dry.

Processing films at temperatures higher or lower than recommended or for longer or shorter times than recommended result in decreased film contrast.

Thermometer should contain alcohol not mercury because they could break and contaminate the processor solutions.

Temperature	**Development time**
68 F	5 min
70 F	4.5 min
72 F	4 min
76 F	3 min
80 F	2.5 min

Changing solutions:

Exhaustion of the developer results from:

1. Oxidation of the developing agent.
2. Depletion of hydroquinone.
3. Buildup of bromide.

- Exhausted developer results in films with low density and contrast.
- When fixer becomes exhausted, silver thiosulfate complexes form and halide ions build up.

- Increased concentration of silver thiosulfate complexes decreases the rate of diffusion of these complexes out of the emulsion.
- The halide ions slow the rate of clearing of unexposed crystals.
- Exhausted fixer results in incompletely cleared films that turn brown with age.

When to change the processing solutions?

A double film packet is exposed for the first patient radiographed after new solutions have been prepared.

One film is placed in the patient's chart and the other is mounted on a view box in the darkroom.

As successive films are processed they are compared with this reference film.

Loss of image contrast and density becomes evident as the solutions deteriorate indicating when the time has come to change them.

Rapid processing chemicals:

- Advantageous in endodontics and emergency.
    - More concentrated solutions.
    - Develop film in 15 sec.
    - Fix film in 15 sec.
    - At room temp.
    - Doesn't have the same degree of contrast as conventionally processed film.
    - They discolor over time.
    - Conventional solutions are preferred for routine use.
    - To improve the contrast and keep them stable in storage, rapidly processed films are placed in conventional fixing solution for 4 minutes and washed for 10 min after viewing.

Automatic Film Processing:

Advantages:

- Time saving (takes 4 to 6 minutes to process a film).
- Doesn't require a dark room because it has a daylight loader.
- Consistent density and contrast.

In order to process the films rapidly:

- The chemical composition of the developer and fixer are modified to operate at higher temperatures than those used for manual processing.
- Higher concentration solutions are used.
- Regular automatic replenishment system is used.
- Rinsing step is eliminated.

The fixer has an additional hardener to help the emulsion withstand the transport system.

Disadvantages:

1. Expensive.
2. Needs regular maintenance.
3. Must process a certain number of films per day, otherwise it will not perform efficiently.
4. High temperature tends to produce chemical fog and rapidly deteriorates the strength of the solutions+.

Automatic Processor Rollers:

1. Transport the film through the developing solutions.
2. Their motion keep the solutions agitated which results in uniform processing.
3. They press on the emulsion, forcing some solution out of it and the emulsion rapidly fills again with solution thus promoting solution exchange.
4. Rollers at the crossover point between the developer and fixer minimize the carryover of developer into the fixer tank which maintains the uniformity of the processing chemicals.

Self-processing Intra-oral films:

Self-developing films are an alternative. The x-ray film is presented in a special sachet, containing developer and fixer. Following exposure the developer tab is pulled, unveiling developer solution, which is milked down towards the film and massaged around it gently. After about 15 seconds, the fixer tab is pulled to release fixer solution, which is similarly milked down to the film. After fixing the used chemicals are discarded and the film is rinsed thoroughly under running water about 10 minutes.

Advantages:

1. No darkroom is needed.
2. Time saving.

Disadvantages:

1. Poor image quality.
2. Image deteriorates rapidly with time.
3. No lead foil inside film packet.
4. Film packet is very flexible and easily bent.
5. Difficult to use with film holders.
6. Expensive.

A rigid plastic backing was manufactured to help reduce the problems of flexibility and lack of lead foil.

Direct Digital Radiography:

Advantages:

1. Lower radiation dose is required.
2. Computer manipulation of the image.
3. Automated image analysis.
4. No need for conventional processing, thus avoiding all processing film faults and the hazards associated with handling the chemical solutions.
5. Storage and archiving of patient information.
6. Teleradiology (transference of images between institutions).

Disadvantages:

1. Expensive.
2. In Direct Digital systems the sensor and the computer have to be connected directly and the connecting cable can make intraoral placement of the sensor difficult.
3. Reduced resolution.
4. Image manipulation can be time consuming and misleading to the inexperienced.
5. Hard copy images may fade with time.
6. Computed or digital images are still 2 dimensional representations of 3 dimensional objects.

REFERENCES:

1. Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The Essential Physics of Medical Imaging: Lippincott Williams & Wilkins; 2011.
2. Bushong, S. C. (2008). Radiologic science for technologists. Canada: Elsevier.
3. Richard R. Carlton, Arlene McKenna Adler (2005) Principles of Radiographic Imaging, Delmar.
4. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.

L.8 Radiographic Errors and Artifacts on the Film

By

Mahmood Al-Fahdawi B.S., M.Sc., Ph.D.

Oral Radiology Teacher, Anbar University

Introduction:

Artifact defined:

- Any opacity on the radiograph that does not correspond to an actual anatomic structure.
- Any misrepresentation of an actual anatomic structure.
- Anything decreasing radiographic quality.

Films with errors should be avoided due to the following reasons: Retake will lead to:

- Expose the patient to unnecessary radiation.
- Waste film and time (money).
- Interfere with accurate interpretation and diagnosis.

Radiographic Errors and Artifacts on the Film:

1. Distorted images: from improper alignment of the tube, object or film.

Vertical elongation: vertical angulation too small.

Foreshortening: vertical angulation too great.

Horizontal overlapping: incorrect horizontal angulation.

2. Finger marks: from improper handling with hands; dark finger marks, developer on fingers fluoride particularly stannous dirt (grease) clear finger marks, fixer on fingers

3. Blurred images: from movement of the patient, film, or tube during exposure. The complete film will be blurred.

4. With a bent film: part of the film will be in focus (usually the crowns) and part will be blurred (elongated).

4.1. When the film is completely bent over the lead foil from the back of the film appears on the front of the film and causes whites lines area, areas usually in the corner of the film closest to the roots.

5. Dark or light films where images are visible: error in any one of the factors controlling density or distance. With the three exposure or three processing errors, the whole film will be affected.

6. Completely clear film: i) machine not switched on ii) malfunction of machine iii) placing film in fixer before developer solution iv) film not taken / exposed.

7. Cone cutting: beam of radiation did not cover film, improper alignment (vertical or horizontal) / OR: long axis of rectangular cone placed horizontal for anterior film or vice versa, OR improper set-up of aligning instruments.

8. Herring bone pattern / Tire Track: film placed wrong way round in mouth. Film will have reduced density and marks / pattern on one side of film. Without the marks - see # 5 above.

9. Double exposure: same film is exposed twice. Often this results in another film not being exposed, thus another film will appear clear. The images may appear superimposed, (parallel) at ninety degree angles to each other or upside-down.

10. Static electricity: films forcibly unwrapped or excessive flexing of film. Seen more often in dry, hot environment. Black “lightning” marks.

11. Crescent shaped black lines: i) fingernail pressure on the film ii) excessive bending the film. Crescent shaped white lines - cracked intensifying screen.

12. Reticulation: the emulsion contracts with time when subjected to great changes (difference of at least 15 degrees) in temperature between the different processing solutions.

13. Undeveloped / clear area on film i) Incomplete immersion of film in developer - linear gray levels along edge - common board question. ii) Films overlapping during processing - outline of film. iii) Fixer on operator's hands - clear finger prints iv) Cone cutting sharply delineated round or straight area v) Film not exposed

14. Scratched film: Emulsion is soft during processing. Long fingernails, careless handling during manual processing, wet films touching other films while being processed or drying.

15. Black borders: i) Wet or leaking packets allow light to enter a poorly sealed edge of film packet. Dry films on removal from mouth. ii) Light due to opening day light loader too soon

16. Black spots: dirt in the duplicating machine (developer drops will be dark)

17. Streaks: i) Improper washing of film hanger ii) Dirty rollers. iii) Heating pad in automatic processor not functioning

18. Radiolucent spots: i) developer drops (dark) ii) powder from the gloves iii) developer chemicals not properly dissolved.

19. Clear spots: i) Air bubbles sticking to film during processing ii) Fixer splashed on film prior to developing iii) Dirt in the intensifying screens

20. Brown film: With time the film will go brown if not left in fixer solution or water bath (final wash) for the required amount of time with manual processing. Also with exhausted fixer solution with automatic processing. When the radiograph is initially processed it will appear "normal".

21. Small, round, irregular, dark dots similar to static electricity - marks due to powder from gloves.

22. Black film: completely exposed to light. Black on one side of the film, hands taken out of automatic processor too soon.

23. Ear rings, nose rings, (metal) dentures, eye glasses etc. will all create radiographic artifacts (double or ghost images) and must be removed before radiographs are taken.

24. Gray film with loss of detail: film fogged, exhausted fixer, insufficient time in fixer solution.

Processing Errors:

Time and temperature problems and solutions:

Error	Appearance	Problem	Solution
Underdeveloped film.	Light	Inadequate development time. Developer solution too cool. Inaccurate timer or thermometer. Depleted developer solution.	Check development time. Check developer temperature. Replace faulty timer or thermometer. Replenish developer with fresh solutions as needed.
Overdeveloped	Dark	Excessive developing time.	Check development time.

film.		Developer solution too hot. Inaccurate timer or thermometer. Concentrated developer solution.	Check development temperature. Replace faulty timer or thermometer. Replenish developer with fresh solutions as needed.
Emulsion Reticulation.	Cracked	Sudden temperature change between developer and water bath.	Check temperature of processing solutions and water bath. Avoid drastic temperature changes.

Chemical contamination problems and solutions:

Error	Appearance	Problem	Solution
Developer spots.	Dark spots.	Developer comes in contact with film before processing.	Use a clean work area in the dark room.
Fixer spots.	White spots.	Fixer comes in contact with film before processing.	Use a clean work area in the dark room.
Yellow brown stains.	Yellow brown color.	Exhausted developer or fixer. Insufficient fixation time. Insufficient washing.	Replenish chemicals with fresh solutions as needed. Use adequate fixation time. Wash for a minimum of 20 minutes.

Film handling problems and solutions:

Error	Appearance	Problem	Solution
Developer cut off.	Straight white border.	Undeveloped portion of film due to low level of developer.	Check developer level before processing.
Fixer cut off.	Straight black border.	Unfixed portion of film due to low level of fixer.	Check fixer level before processing.
Overlapped films.	White or dark areas appear on film where overlapped.	Two films contacting each other during processing.	Separate films so that no contact takes place during processing.
Air bubbles.	White spots.	Air trapped on film surface after being placed in the processing solutions.	Gently agitate film racks after placing in processing solutions.
Fingernail artifact.	Black crescent shaped marks.	Film emulsion damaged by operator's fingernail during rough handling.	Gently handle films by the edges only.

Fingerprint artifact.	Black fingerprint.	Film touched by fingers that are contaminated with fluoride or developer.	Wash and dry hands thoroughly before processing.
Static electricity.	Thin black branching lines.	Occurs when a film packet is opened quickly. Occurs when a film packet is opened before the radiographer touches a conductive object.	Open film packets slowly. Touch a conductive object before unwrapping film.
Scratched film.	White lines.	Soft emulsion removed from film by a sharp object	Use care when handling films and film racks.
Developer spots.	Dark spots.	Developer comes in contact with film before processing.	Use a clean work area in the dark room.
Fixer spots.	White spots.	Fixer comes in contact with film before processing.	Use a clean work area in the dark room.
Yellow brown stains.	Yellow brown color.	Exhausted developer or fixer. Insufficient fixation time. Insufficient washing.	Replenish chemicals with fresh solutions as needed. Use adequate fixation time. Wash for a minimum of 20 minutes.

Lighting problems and solutions:

Error	Appearance	Problem	Solution
Light leak.	Exposed area appears black.	Accidental exposure of the film to white light.	Examine film packets for defects before using. Never unwrap films in the presence of white light.
Fogged film.	Gray; lack of detail and contrast.	Improper safe lighting. Light leaks in dark room. Outdated films. Improper film storage. Contaminated solutions. Developer solution too hot.	Check the filter and bulb wattage of the safe light. Check the dark room for light leaks. Check the expiration date on film packages. Store films in a cool dry protected area. Avoid contaminated solutions by covering tanks after each use. Check temperature of developer.

REFERENCES:

1. Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The Essential Physics of Medical Imaging: Lippincott Williams & Wilkins; 2011.
2. Podgorsak, Ervin B. Radiation Physics for Medical Physicists: Second Edition, 2010.
3. Weisstein, Eric W. "Radiation". Eric Weisstein's World of Physics. Wolfram Research. Retrieved 11 January 2014.
4. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.

L.11 **Radiation biology and radiation protection**

By

Mahmood Al-Fahdawi B.S., M.Sc., Ph.D.

Oral Radiology Teacher, Anbar University

Biological Effects of Ionizing Radiation at Cell Level:

Radiation exposure affects the center of life; the cell, then eventually the chromosomes: the critical target is DNA ionizing.

Chromosomes in cells are made up of many strands of DNA that are twisted, forming a double helix.

A single strand of DNA consists of 2 sugar-phosphate molecular backbones that are loosely bonded by complementary nitrogenous bases. There are 2 complementary nitrogenous base pairs: adenine, which bonds with thymine, and cytosine, which bonds with guanine. In all, there are about 3 billion base pairs and 35000 genes in the human genome.

Radiation energy is transferred to the irradiated tissues primarily by Photoelectric and Compton's processes which produce ionizations and excitations of essential cell molecules such as DNA, enzymes, ATP, coenzymes, etc.

The functions of these molecules are altered. The cells with damaged molecules cannot function normally. The severity of biological effect is related to the type of molecule absorbing radiation. Effect on DNA molecule is more harmful than on cytoplasmic organelles.

Mechanisms of radiation damage:

Two mechanisms of radiation damage, mostly on DNA:

I. Indirect damage.

Water molecule is ionized. The ions, H_2O^+ and H_2O^-, are very unstable and break up into OH free radicals. OH free radical contains an unpaired electron in the outer shell and is highly reactive: reacts with DNA.

Free radicals may also combine with each other to produce hydrogen peroxide

$$OH\bullet + OH\bullet \text{-------->} H_2O_2$$

Hydrogen peroxide is a cell poison that may contribute to biological damage. 75% of radiation-caused DNA damage is due to OH free radical.

These free radicals lead to oxidation of DNA by OH radicals, if chemical restoration occurs so no effect, if not permanent damage in DNA lead to biological effects; genetic effects and somatic effects: cancer – sterility.

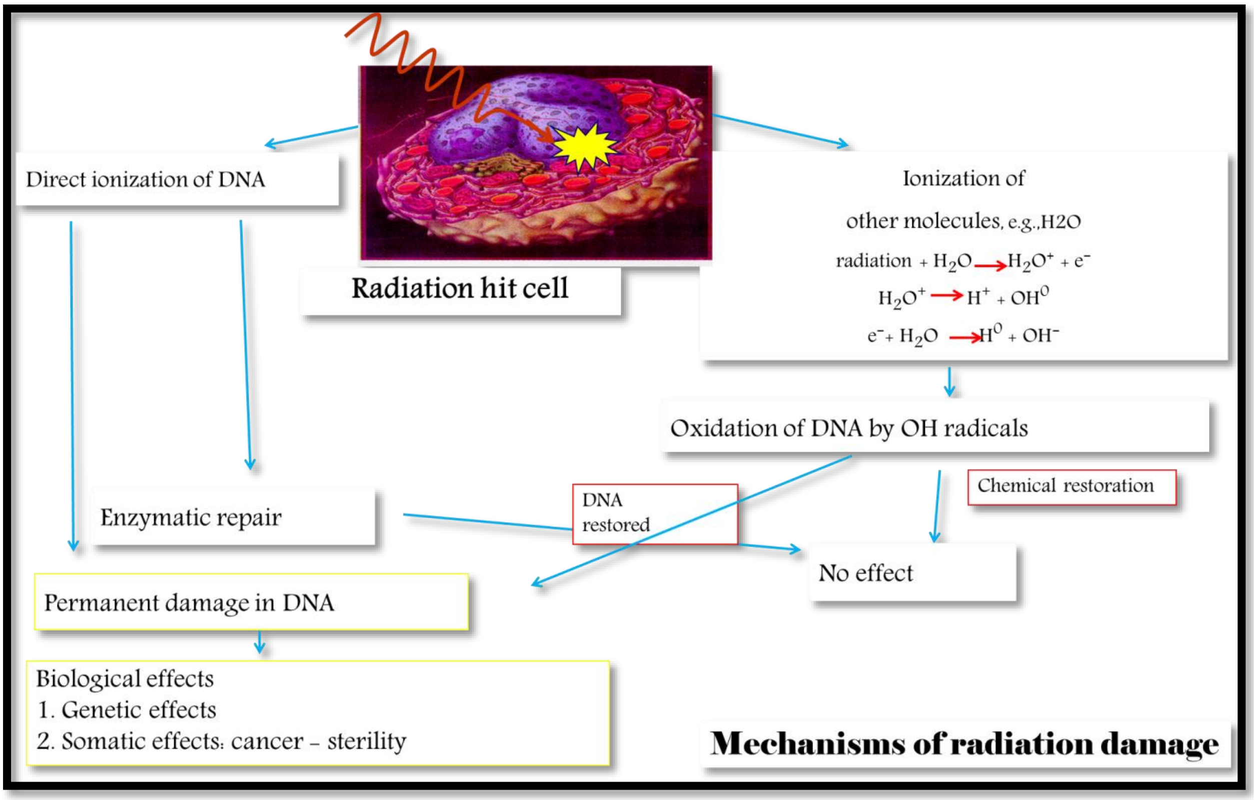
Radiation $+H_2O$..... $H_2O^+ + e^-$

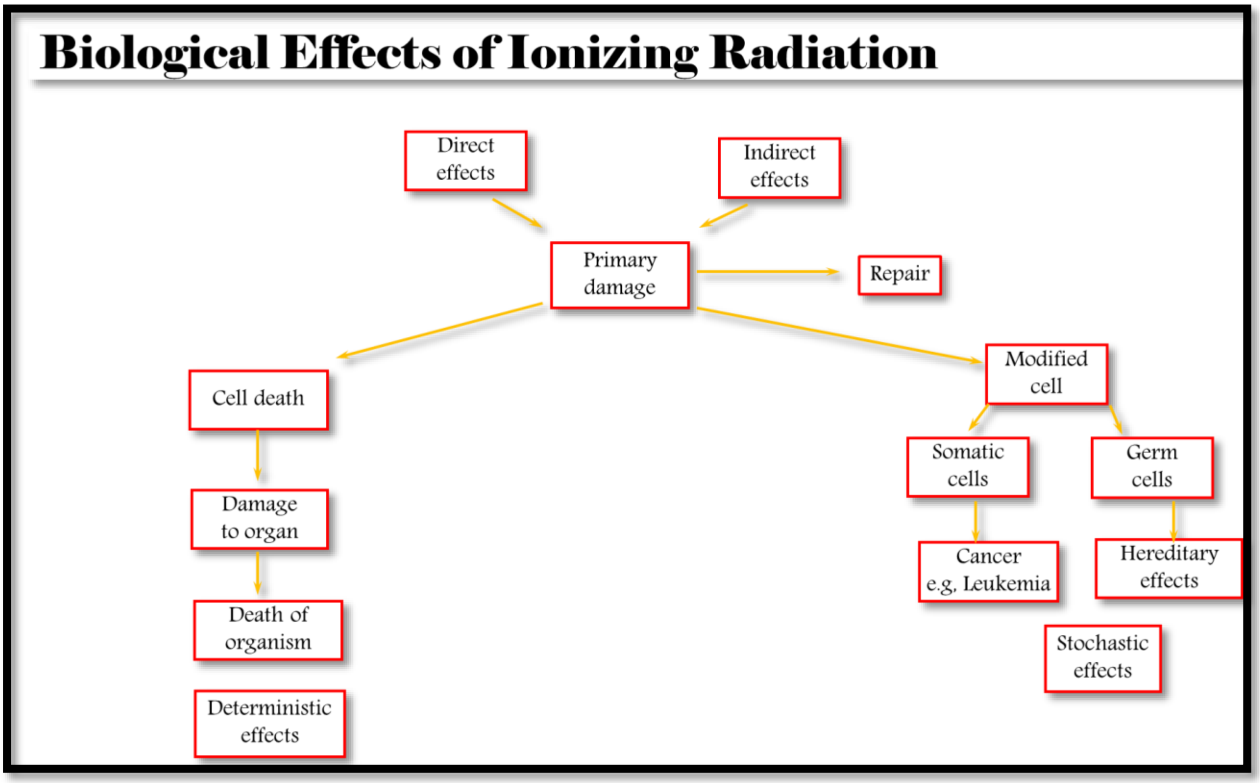
H_2O^+ .....> $H^+ + OH^0$

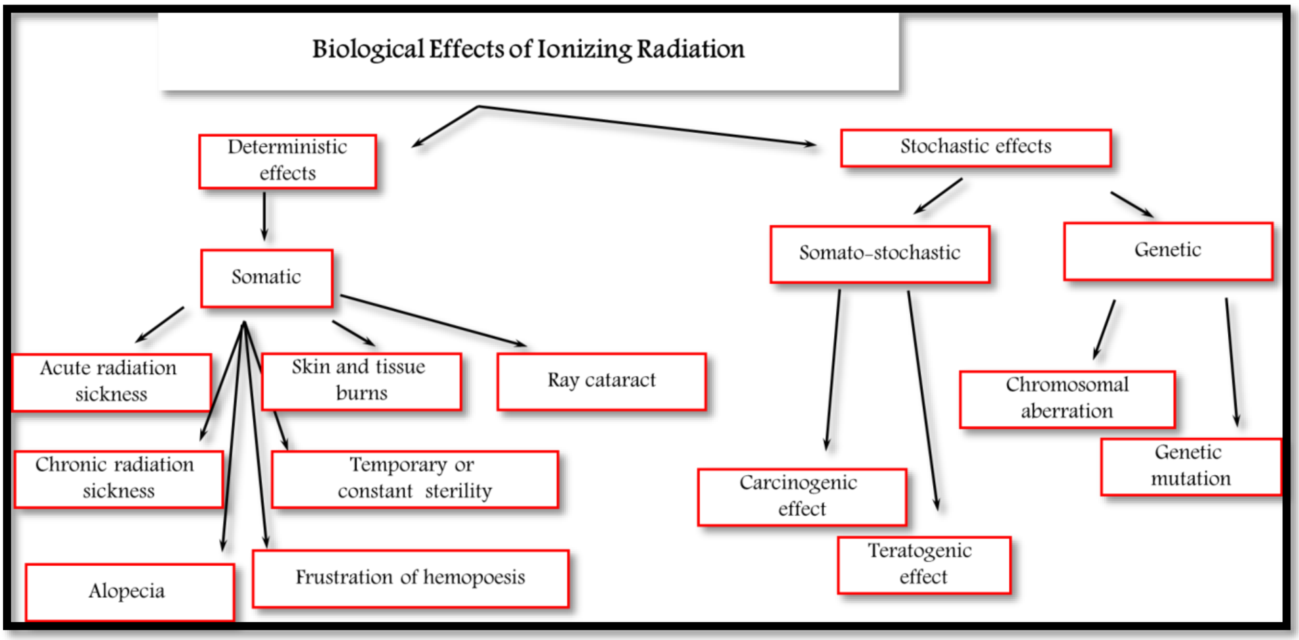
$e^- + H_2O$ .....> $H^0 + OH^-$

II. Direct damage

- DNA molecule is struck by radiation, ionized, resulting in damage. Radiation hit cell, lead to direct ionization of DNA; if enzymatic repair occurs there is no effect, and if not permanent damage in DNA lead to biological effects; genetic effects and somatic effects: cancer – sterility.

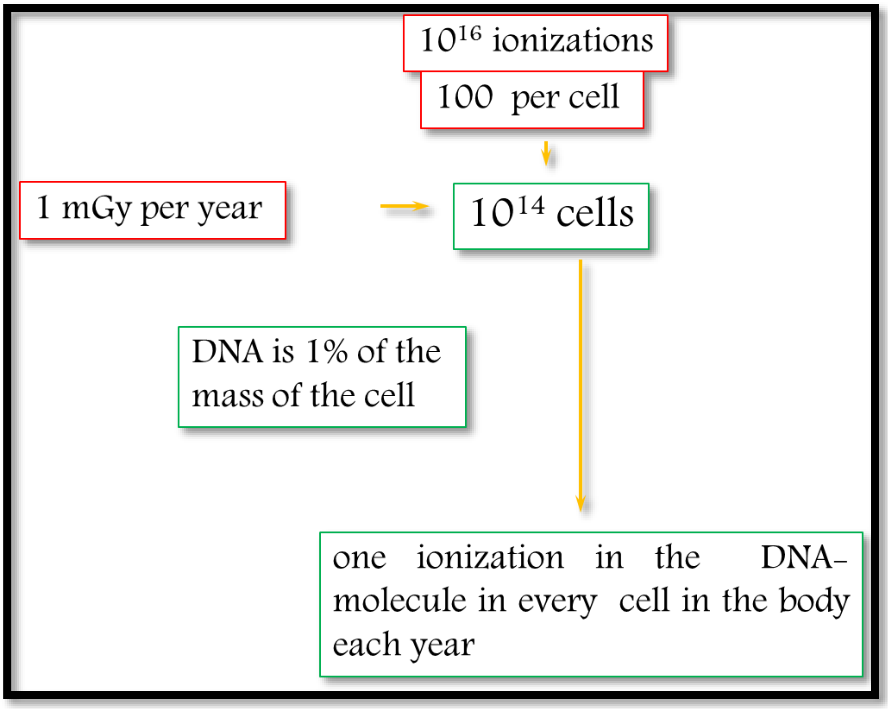






Natural Annual Ionization:

- The human body contains about 10^{14} cells.
- An absorbed dose of 1 mGy (milliGray) per year (natural sources) will produce about 10^{16} ionizations, which means 100 ionizations per cell in the body.
- If we assume that the mass of DNA is 1% of the mass of the cell, the result will be one ionization in the DNA-molecule in every cell in the body each year.



What Follows Chromosome Damage?

The cell might:

1. Repair mild damage.
2. Have some mild damage that sits inactive until another agent interacts with the same cell.
3. If it is a reproductive cell like sperm or egg cells having damage to the genetic code, that doesn't show up until future generations.
4. Have some damage, causing its multiplication to become a cancer.
5. Stop functioning.
6. Be killed.

Order of magnitudes:

- 999 of 1000 lesions are repaired.
- 999 of 1000 damaged cells die (not a major problem as millions of cells die every day in every person).
- Many cells may live with damage (could be mutated).

Deterministic Effects on Cells

1. Intracellular Structures
2. Chromosome Aberrations
3. Cell Replication
4. DNA Damage
5. Apoptosis

Chromosome Breaks

I. Point mutations:

- Effect of radiation on individual gene is referred to as point mutation.
- The effect can be loss or mutation in a gene or a set of genes.
- The implication of such a change is that the cell may now exhibit an abnormal pattern of behavior.

II. Chromosome alterations:

- Several kinds of alterations in the chromosomes have been described. Most of these are clearly visible under the microscope.
- The effect upon chromosomes can result in the breaking of one or more chromosomes. The broken ends of the chromosome seem to possess the ability to join together again after separation.
- Such damage may be repaired rapidly in an error-free fashion by cellular repair processes (restitution) using the intact second strand as a template.
- However, if the separation between broken fragments is great, the chromosome may lose part of its structure (deletion).
- If more than one break, the broken fragments may join in different combinations.
- Inversion of the middle segment followed by recombination

III. Double-strand breakage:

- When both strands of a DNA molecule are damaged. Sections of one broken chromosome may join sections of another broken chromosome.

- A large proportion of damage will result in disrepair that can result in the formation of gene and chromosomal mutations that may cause malignant development.

Chromosome alterations:

- Formation of a ring and fragments followed by replication of chromosomes.
- Interchange between two chromosomes forms a chromosome with two centromeres and fragment followed by replication.

Recovery

Cell recovery from DNA damage and the bystander effect involves enzymatic repair of single-strand breaks of DNA. Because of this repair, a higher total dose is required to achieve a given degree of cell killing when multiple fractions are used (e.g., in radiation therapy) than when the same total dose is given in a single brief exposure. Damage to both strands of DNA at the same site is usually lethal to the cell.

Arrested Mitosis

- Ionizing radiations also affect cell division, resulting in arrested mitosis and, consequently, in retardation of growth. This phenomenon is the basis of radiotherapy of neoplasms.
- The extent of arrested mitosis varies with the phase of the mitotic cycle that a cell is at the time of irradiation. Cells are most sensitive to radiation during the last part of interphase and the early part of prophase.

Radiation Effects at Tissue Level

Somatic effects:

- Somatic effects include responses of all irradiated body cells except the germ cells of the reproductive system.
- Somatic effects are deleterious to the person irradiated.
- Somatic effects may be stochastic or deterministic.
- Somatic tissues do not always react to doses of ionizing radiation so as to give immediate clinically observable effects.
- There may be a time-lapse before any effects are seen.

- Basically, somatic effects are classified in two categories:
  - Early (Acute or immediate) effects.
  - Late (Delayed or chronic) effects.

Early Somatic Effects

- Appear rather soon after exposure to a single massive dose of radiation or after several smaller doses of radiation delivered within a relatively short period of time.
- In general, effects that appear within 60 days of exposure to radiation are classified as early effects.

Late Somatic Effects

- Late effects may occur anywhere from two months to as late as 20 years or more after exposure to radiation.
- The time lapse between the exposure to radiation and the appearance of effects is referred to as the "latent period."
- In radiobiology, the term "latent period" is usually used only in relation to stochastic effects (malignancy).

Variables in Somatic Effects

The magnitude of somatic effects depend on the following variables:

1. Cellular and tissue variability.
2. Source of radiation (External and Internal).
3. Individual variability.
4. Extent of exposure (Full or Partial Body).
5. Total dose.
6. Dose rate.
7. Age at exposure.

Effects of Radiation Therapy on Oral Tissues:

Adult teeth:

- Very resistant to the direct effect of radiation exposure.
- No effect on the crystalline structure of enamel, dentin and cementum.

➢ Radiation caries:

- In individuals whose salivary glands have been damaged resulting in xerostomia. Secondary to changes in saliva; i.e., reduced flow, pH and buffering capacity and increased viscosity.

Developing teeth:

- <10 Gy has very little or no visible effect.

Effects to an infant may include:

1. Destruction of tooth bud.
2. Tooth malformation.
3. Delay in eruption.

Bone:

- The most serious complication; Jaw **osteoradionecrosis**. This is primarily due to damage to the blood vessels of the jaw and consequent decreased capacity of the bone to resist infection. Tooth extraction or other injury and possibility of bone infection and necrosis becomes very high. More common in the mandible than in maxilla.

Salivary glands: Xerostomia: Marked and progressive loss of salivary secretion. The mouth becomes dry (xerostomia) and tender. The pH of saliva falls below normal (5.5 as compared to 6.5 in normal saliva). The salivary changes influence oral microflora, and secondarily contribute to the formation of radiation caries. Whether xerostomia is temporary or permanent depends upon the volume of glands exposed.

Mucosa: Mucositis: At 3rd or 4th week of RT, oral mucosa becomes red and inflamed (mucositis).

As the RT continues, mucosa forms yellow pseudomembrane. Secondary infection by Candida albicans is a common complication. Mucositis is most severe at the end of the treatment period. Healing begins soon after treatment and is usually complete in about two months after therapy. The mucosa tends to become atrophic, thin, and relatively avascular permanently.

Taste buds:

- Taste acuity is reduced or lost in about 4 weeks into the radiation treatment. In general, bitter and sour flavors are more severely affected when posterior third of the tongue is irradiated, salt and sweet when anterior third is irradiated. Complete recovery of taste usually occurs in two to four months following treatment completion.

REFERENCES:

1. Bushberg JT, Seibert JA, Leidholdt EM, Boone JM: The Essential Physics of Medical Imaging: Lippincott Williams & Wilkins; 2011.
2. Matthews EP. Radiation Physics, Biology, and Protection. Radiol Technol. 2019 May;90(5):471-485.
3. Podgorsak, Ervin B. Radiation Physics for Medical Physicists: Second Edition, 2010.
4. Weisstein, Eric W. "Radiation". Eric Weisstein's World of Physics. Wolfram Research. Retrieved 11 January 2014.
5. White SC, Pharoah MJ: Oral radiology: principles and interpretation: Elsevier Health Sciences; 2014.