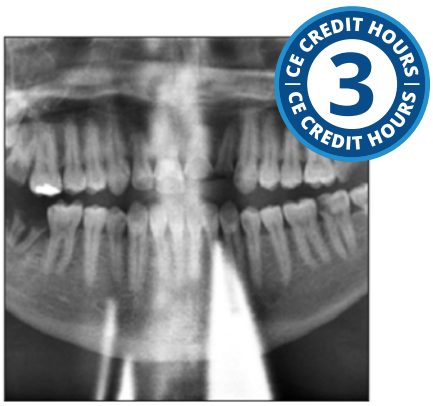
Practical Panoramic Imaging



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Conflict of Interest Disclosure Statement

- The authors report no conflicts of interest associated with this course. They have no relevant financial relationships to disclose.

Introduction – Panoramic Imaging

The primary focus of this continuing education course is to broaden awareness of panoramic radiographic imaging technique, error recognition and error correction.

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Overview

Panoramic radiographic imaging technique, error recognition and error correction are the primary areas of emphasis in this course. The components involved in the optimal production of a panoramic image will be outlined. A technique for acquiring an image will be presented. Interpretation of the panoramic image will include basic anatomic structures as well as the identification and correction of imaging errors. Finally, a summary of common positioning errors will be provided to facilitate the assessment of unacceptable images incorporating key features of errors ranging from patient preparation to technique problems. This course is provided to enhance the participant's understanding of common errors and their correction with the goals to improve image quality and reduce retakes and, thus, reduce exposure to the patient.

Learning Objectives

Upon completion of this course, the dental professional should be able to:

- Discuss radiographic selection criteria and the indications for panoramic imaging.
- Compare and contrast panoramic and intraoral imaging.
- Outline the advantages and limitations of panoramic radiographic imaging.
- Describe the concepts involved in panoramic image formation.
- Outline the procedures required for correct machine and patient preparation, patient positioning and panoramic unit operation.
- Become familiar with anatomic structures that are recorded on panoramic images.
- Identify and propose corrective action for common panoramic image errors.
- Demonstrate ability to recognize and correct common errors via a self-assessment exercise.

Indications for Panoramic Imaging

Selection criteria guidelines are recommendations developed to assist the dentist in the appropriate prescription of dental radiographic examinations. In 2012, the American Dental Association (ADA) and the Food and Drug Administration (FDA) revised these recommendations, updating the previous version published in 2004.[1] In the updated version, the use of panoramic examinations in combination with posterior bitewings is provided as an option for imaging new patients in the child (transitional dentition), adolescent and adult categories. The application of the guidelines should be based

on a clinical examination with consideration given to the patient's signs, symptoms and oral/medical histories, as well as vulnerability to environmental factors that may affect oral health.[1] The resultant diagnostic information should help the dentist determine the type of imaging needed, if any, and its frequency. Dentists should prescribe radiographs only when they expect that the additional diagnostic information will affect patient care.[1] In addition, panoramic imaging may be appropriate in the assessment of growth and development, craniofacial trauma, third molars, implants, osseous disease or large, extensive bony lesions and the initial evaluation of edentulous ridges and temporomandibular joint disorders. Panoramic imaging is also a useful alternative technique for imaging patients with severe gag reflexes, large extensive tori or when the intraoral receptor cannot be tolerated inside the mouth.

By comparison, intraoral periapical and bitewing surveys are preferred for caries detection, identification of periapical pathology and the detection of periodontal lesions with furcation involvement. A full mouth intraoral radiographic survey is preferred when the patient has clinical evidence of generalized oral disease or a history of extensive dental treatment.[1,2]

Panoramic radiographic images alone or in combination with bitewings radiographs are commonly used for routine screening of all new adult patients. In 2002, Rushton et al. questioned this approach.[3,4] They found that approximately one-fifth of patients received no benefit from indiscriminate use of panoramic radiography. This proportion increased to one-fourth when asymptomatic patients were examined in isolation. They also found that clinical factors obtained from the patient history and examination modestly improved the chances of a high diagnostic yield from panoramic images. The clinical factors identified as the best predictors of useful diagnostic yield included clinical suspicion of teeth with periapical pathology, partially erupted teeth, evident carious lesions, dentition (dentate, partially dentate, edentulous), presence of crowns and suspected unerupted teeth.

In a 2012 study, Rushton et al. assessed the added value of screening panoramic radiographs compared to intraoral radiography in adult dentate patients in a primary care setting.[5] This study reaffirmed that there was no net diagnostic benefit to the patient with the use of panoramic radiographs as a routine screening tool.[5]

More recently, Benn and Vig published a study which estimated US dental practice radiographic-associated cancer cases.[6] Findings of clinical relevance included a trend in orthodontic treatment to replace lower dose panoramic and cephalometric radiography with higher dose cone beam computed tomography and the lack of adherence to dose reduction measures by US dentists, such as the use of selection criteria to reduce radiographic-associated cancer cases.[6]

It is not only prudent but also necessary for the dentist to follow selection criteria guidelines so that the selected survey, whether intraoral, panoramic or a combination thereof, is appropriate for the patient, will produce a high yield result while minimizing radiation exposure.

Comparisons to Intraoral Radiography

While panoramic radiographic imaging has several features in common with intraoral radiographic imaging, exist in the operation of the equipment and the technique used.

Equipment Differences

Panoramic x-ray units differ from intraoral x-ray units in the following ways: exposure factors, image receptor, x-ray source, patient positioning and image projection.

Exposure Factors

Both intraoral and panoramic x-rays machines have the following exposure factor controls: milliamperage (mA), kilovoltage (kVp) and time. The primary difference between the two types of machines is the control of exposure parameters. Typically, intraoral x-ray units usually have fixed mA and kVp controls while the exposure is altered by adjusting the time for specific intraoral projections and regions of the jaws. Panoramic x-ray unit exposure is controlled by adjusting complimentary parameters; the exposure time is fixed while the kVp and the mA are adjusted according to patient size, stature, and bone density. Although the principles of operation are identical, the exposure control panel is more complex in its format.

Table 1. Selection Criteria Guidelines.[1]

Type of Patient Encounter	Child with Primary Dentition	Child with Mixed Dentition	Adolescent with Permanent Dentition	Adult Dentate Partially Dentate	Adult Edentulous
New Patient	Individualized exam - selected periapicals or occlusals if indicated Bitewings if contacts are closed	Individualized exam – bitewings & panoramic or bitewings & selected periapicals	Individualized exam – bitewings & panoramic or bitewings & selected periapicals FM survey if indicated	Individualized exam – bitewings & panoramic or bitewings & selected periapicals FM survey if indicated	Individualized exam based on clinical signs & symptoms
Recall with Clinical Caries or Increased Caries Risk	Bitewings at 6-12-month intervals if contacts are closed	Bitewings at 6-12-month intervals if contacts are closed	Bitewings at 6-12-month intervals if contacts are closed	Bitewings at 6-18-month intervals	Not Applicable
Recall with No Clinical Caries or Low Caries Risk	Bitewings at 12-24-month intervals if contacts are closed	Bitewings at 12-24-month intervals if contacts are closed	Bitewings at 18-36-month intervals	Bitewings at 24-36-month intervals	Not Applicable
Recall with Periodontal Disease	Clinical judgment for need & type of images May include selected periapicals and/or bitewings as indicated	Clinical judgment for need & type of images May include selected periapicals and/or bitewings as indicated	Clinical judgment for need & type of images May include selected periapicals and/or bitewings as indicated	Clinical judgment for need & type of images May include selected periapicals and/or bitewings as indicated	Not Applicable
New or Recall Monitor Growth & Development/Assess Dental/Skeletal Relationships	Clinical judgment for need & type of images for assessment	Clinical judgment for need & type of images for assessment	Clinical judgment for need & type of images for assessment Panoramic or periapicals for 3rd molars	Usually not indicated	Usually not indicated
Patients with Other Circumstances	Clinical judgment for need & type of images for assessment or monitoring	Clinical judgment for need & type of images for assessment or monitoring	Clinical judgment for need & type of images for assessment or monitoring	Clinical judgment for need & type of images for assessment or monitoring	Clinical judgment for need & type of images for assessment or monitoring

American Dental Association and Food and Drug Administration. Dental radiographic examinations: Recommendations for patient selection and limiting exposure. American Dental Association Council on Scientific Affairs and U.S. Department of Health and Human Services, Food and Drug Administration. Revised 2012.

- **Milliamperage (mA) Control** - regulates the low voltage electrical supply by adjusting the number of electrons flowing in the electrical circuit. Altering the milliamperage setting influences the quantity of x-rays produced and image density or darkness. *A 20% difference is required to visibly alter image density.*

- **Kilovoltage (kVp) Control** – regulates the high voltage electrical circuit by adjusting the potential difference between the electrodes. Altering the kilovoltage setting influences the quality or penetration of the x-rays produced and image contrast or differences in density. *A 5% difference is required to visibly alter image density.*

- **Time Control** – regulates the period over which electrons are released from the cathode. Altering the time setting influences the quantity of x-rays and image density or darkness in intraoral radiography. *The exposure time in panoramic imaging is fixed for a specific unit and the entire exposure cycle ranges from 16 to 20 seconds in length.*

Automatic Exposure Control (AEC), a feature of some panoramic x-ray machines, measures the amount of radiation that reaches the image receptor and terminates the preset exposure when the receptor has received the required radiation intensity to produce an acceptable diagnostic image.[2,7] AEC serves to adjust the amount of radiation delivered to the patient as well as optimize image contrast and density.

X-ray Source and Other Factors

Intraoral x-ray units have a round or rectangular x-ray collimator with the projected beam being slightly larger than the intraoral receptor. In comparison, panoramic x-ray units have a narrow vertical slit aperture. With intraoral x-ray units, the vertical and horizontal angle of the PID (position indicating device) is adjusted for each projection and centered over the image receptor. The panoramic x-ray tubehead is fixed at a negative angle (approximately -10°) and rotates behind the patient's head during the exposure cycle.

Figure 1. Digital Panoramic Unit Control Panel.
Source: 2009 Proline Panoramic XC, Planmeca

Figure 2. Digital Panoramic X-ray Unit.
Source: 2009 Proline Panoramic XC, Planmeca

Figure 3. Intraoral X-ray Unit.
Source: 2002 Heliodent DS, Sirona

Image Receptors

Digital Image Receptors

Panoramic x-ray systems are available that use either linear array charge-coupled device (CCD) or complementary metal oxide semi-conductor (CMOS) detectors as well as photostimulable phosphor plate (PSP) receptors. CCD/CMOS and PSP receptors are used for intraoral radiography as well but with altered sizes and receptor designs. The digital panoramic imaging method is comparable to conventional panoramic radiography but the receptor, processing, display, storage and transmission capabilities differ from film-based imaging.[2,8] Both types of digital image receptors and film will produce diagnostic results when properly utilized.

Direct Digital Image Receptors

CCD/CMOS linear array designs arrange the detector in a grid with the same vertical dimension as panoramic film but only a few pixels wide. The vertical sensor is moved around the patient opposite to the x-ray source and captures the image one vertical line at a time. In the subsequent photographs, a CCD sensor system is used to capture the image. To initiate the process, a patient file must be created in the computer software system. The patient is aligned in the same head positions as required in film-based panoramic x-ray machines. The computer processes the image as it is acquired. Then, the image is displayed on the computer monitor in real time. The image is archived in the patient database. The acquired images can be viewed in diverse ways through the application of software enhancement tools.

Figure 4. Direct Digital Panoramic Imaging

Photostimulable Phosphor Plate (PSP)

PSP sensors consist of a rare earth phosphor, barium europium fluorohalide, coated onto a polyester base. A PSP plate is inserted into a cassette just like film but without the intensifying screens. The image is captured on the phosphor plate and the energy is stored on the plate until it released during a laser scanning process. When a helium-neon laser beam scans the PSP plate, the energy is released in the form of blue florescent light.[8] The emitted light is captured, intensified by a photomultiplier tube and converted into digital data. PSP plates are reusable but must be exposed to light to erase remnant energy. Recent developments include faster plate scanning and erasure of the plate during the scanning process. It is important to scan the exposed plate without delay as white light or delayed scanning can degrade the result.[8,9] PSP imaging is considered an indirect digital imaging method because the data is captured in an analog format like film and then converted into digital data via the scanning process.

The obvious advantage of digital panoramic imaging, particularly direct digital panoramic imaging, is elimination of the darkroom including machine cleaning and maintenance, chemical handling, and solution change as well as associated processing errors. Other advantages include timesaving, electronic

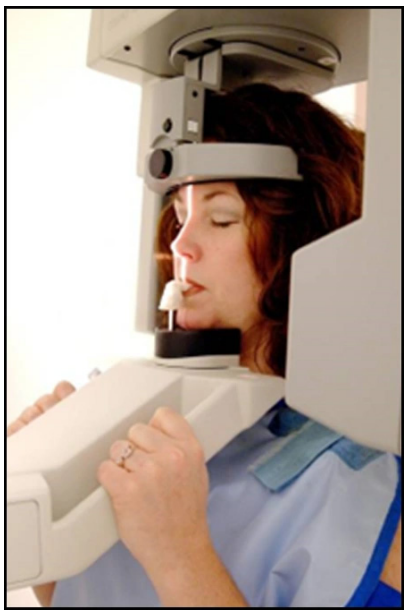


Figure 5. Direct Digital Panoramic Imaging

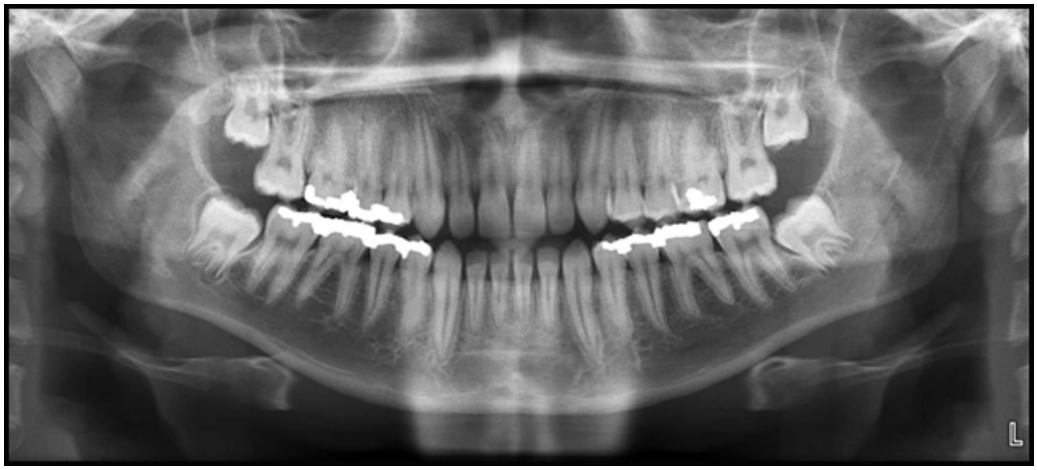


Figure 6.

image storage and transfer, the ability to enhance the captured image with various tools (e.g. density, contrast, measurement, image reversal manipulations) and teleradiography capabilities for the purposes of consultation, insurance, or referral.

However, the image quality regardless of receptor remains dependent upon proper patient preparation, patient positioning and exposure selection to produce optimal results and to avoid retakes.

Radiographic Film

Film used for panoramic radiography is more sensitive and packaged differently than intraoral film. The film is either 5" or 6" x 12" (15 x 30 cm) in size. Since the film does not have protective outer wrappings, it must be housed in a cassette holder during exposure. Cassette holders are rigid or flexible configurations with intensifying screens on the internal walls. Screens have a crystalline phosphor layer that produces visible light when exposed to x-rays. The phosphor layer overlays the reflective

Figure 7. Photostimulable Phosphor Plate.
Emulsion or exposure side – Blue
Non-exposure side - Black

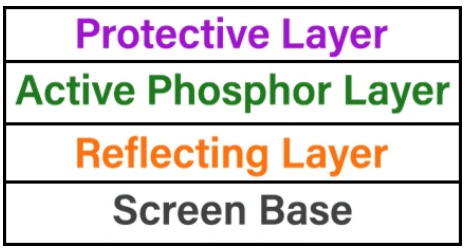


Figure 8. Intensifying Screen.
Diagrammatic cross-section of screen

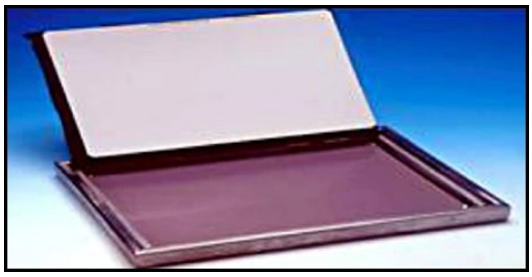


Figure 9. Rigid Cassette with Film.
Open rigid cassette showing screen (white) and film (purple) surfaces.

Figure 10. Flexible Cassette with Panoramic Film.
Partially open flexible cassette showing screen (white) and film (purple) surfaces.

layer, which reflects the light back to the film and both are coated onto a firm plastic base. A protective layer covers the phosphor layer to reduce damage and wear.

Intensifying screens *intensify* the effect of a single x-ray photon by converting it into many light rays. It is the combination of x-rays and light rays that produces the latent image and reduces exposure to the patient. The color of the light emitted by the screens is related to the type of phosphor. Rare earth elements such as lanthanum or gadolinium fluoresce a lime green light and are the preferred and most commonly used screen material. Screen film is packaged in boxes containing 50-100 films and must be managed in a darkroom. A single film is loaded between the screens, the cassette is latched closed prior to leaving the darkroom and the cassette is placed into a cassette holder. The screen film type and intensifying screen fluorescence must be matched to produce a diagnostic image.

For film-based panoramic imaging, quality results are dependent on proper film storage and quality processing techniques. Quality image processing relies on the strength, volume, and temperature of the processing chemistry. Properly maintained and replenished solutions at the recommended time and temperature are mandatory. Optimal performance depends on daily, weekly, and monthly roller/unit cleaning and solution replenishment or change. In addition, special chemical formulations are needed for processing films at higher temperatures and to accommodate roller transport of the film.

Quality Assurance

To ensure consistent high-quality panoramic images, a quality assurance program should be in place and conducted by qualified personnel. Radiographic quality assurance procedures include regular testing, planned monitoring and scheduled maintenance of x-ray equipment, image receptors and darkroom conditions and processing if film-based imaging is employed.

X-ray machines should be inspected periodically for x-ray output, kilovoltage calibration, half value layer, timer accuracy, milliamperage reproducibility, and collimation as required by state law. Operators must be qualified and credentialed according to state regulations.

The American Academy of Oral and Maxillofacial Radiology has published several articles[10,11] that provide guidance in the assessment of and compliance with recommended quality assurance procedures and radiation safety measures, particularly in regard to film-based imaging.

It is recommended that a retake log be maintained to help monitor the number of retakes and the errors committed. Identification of recurring errors indicates a need for continuing education and in-service staff training to eliminate such errors.

Patient Preparation

Regardless of the use of digital or film-based panoramic imaging, the patient must be prepared properly prior to the procedure. The first step is to explain the general aspects of the procedure to the patient. The clinician will need to reinforce and coach the patient during the procedure. Additional pre-exposure instructions are necessary to avoid the production of unwanted artifacts and to ensure patient cooperation.

For intraoral radiography, the patient must be instructed to remove facial jewelry in the beam path (for instance, nose rings or large earrings), eyeglasses and intraoral prostheses. With panoramic imaging, all metallic objects from the head and neck region must be removed including those items described above (Figure 11). Examples include earrings, tongue rings, necklaces, napkin chains, barrettes,

hairpins, intraoral prostheses, and hearing aids must be removed. These items would produce radiopaque artifacts on the image if left in place during exposure. Generally speaking, metallic objects located above the top of the ear line will not interfere with quality imaging. The clinician should take care to safely store these items and return them to the patient when the process is complete.

Figure 11. Removal of metallic head and neck objects.

Patient Protection

The clinician should explain the procedural steps to the patient prior to machine entry and head positioning so that the patient can anticipate what will happen next and will not be alarmed by the mechanical function of the panoramic machine. The clinician should place the panoramic lead apron fully clearing the back of the neck, region; high in front, low in back. Note that the panoramic lead apron has a poncho-type configuration different from lead shields used in intraoral radiography. The preferred panoramic lead (or lead-equivalent) apron has a front and back panel of the same length. If the panoramic lead apron has front and back panels of different length, it is best practice to place the long panel on the patient's back and the short panel in the front because the x-ray beam enters from behind the patient's head. **Do Not Use a THYROID COLLAR.** The use of a thyroid collar or improper lead apron placement will block the x-ray beam and prevent imaging of structures at or near the midline. The clinician must keep in mind that the x-ray beam enters from behind the patient's head in a lingual to labial direction, opposite of intraoral imaging.

The purpose of the lead apron is to reduce the somatic exposure of radiosensitive tissues and minimize genetic exposure to the reproductive organs. In the head and neck region, the most radiosensitive tissues are the thyroid and salivary glands and the hemopoietic tissues of the bone marrow located in the mandible and the sternum. Because of the nature of the panoramic exposure, both the salivary glands and mandible are irradiated, therefore, the role of the lead apron is to provide maximum shielding of the remaining radiosensitive organs. In addition, it should be remembered that the x-ray beam is directed from behind the patient's head and directed slightly upward. Hence the greatest risk to these tissues is from scatter radiation.

Figure 12. Panoramic lead apron with full length front and back panels.

Figure 13. Intraoral lead apron with thyroid collar.

Figure 14.

Dose Comparisons

Exposure from diagnostic imaging is often compared to environmental exposure from naturally occurring radiation and other artificial sources such as consumer products. Collectively these natural and artificial sources are described as background radiation. A typical four-film bitewing survey using PSP receptors or F speed film and rectangular collimation is equivalent to approximately a half day of background radiation.[2,10] By comparison, a panoramic survey is equivalent to approximately a half to full day of background radiation depending on the machine and background radiation standards.[2,12] Unlike intraoral digital imaging, the use of digital receptors for panoramic imaging does not result in significant dose reduction compared to film-based panoramic systems using rare earth intensifying screens.[12,13]

Patient Positioning Requirements

The basic head alignment used in panoramic imaging is comparable to the recommended head position for maxillary periapical and bitewing radiographic images. The patient's head should be adjusted so that the midsagittal plane is perpendicular to the floor and the Frankfort horizontal or occlusal plane is parallel to the floor.

However, with panoramic imaging several additional alignment planes are necessary to achieve a consistent diagnostic result. The patient's head must be centered in three different planes in order to uniformly record the maxillofacial complex. The head alignment planes include the midsagittal, Frankfort horizontal/occlusal and the anteroposterior. Each will be discussed below.

Midsagittal Plane

The midsagittal (horizontal/side-to-side) plane is positioned perpendicular or at a right angle to the floor and centered right to left. Many machines display a vertical alignment light or mirror to adjust the alignment of the midsagittal plane so that the right and left sides of the dental arches are equally displayed.

Frankfort Horizontal/Occlusal Plane

Typically, the Frankfort plane (superior border of the external auditory meatus to the infraorbital rim) or plane of occlusion (vertical/up-down plane) is positioned parallel to the floor in panoramic imaging. The Tragal-canthus plane (tab in ear to outer corner of the eye), and the Ala-tragus (corner of nose to tab in the ear) plane are used to align the vertical position of the head as well. Some machines provide a horizontal alignment light to help assess the proper vertical position of the head. The patient's forehead and chin should be in the same vertical plane.

Figure 15. Midsagittal Plane.

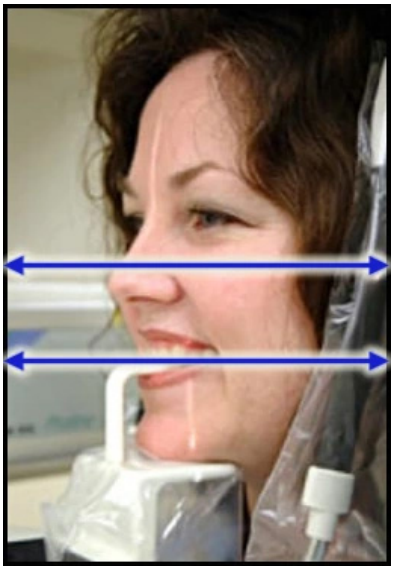


Figure 16. Frankfort and Occlusal Plane.

Anteroposterior Plane

Anteroposterior (forward-backward) or AP plane is aligned with a specific landmark that varies among panoramic machines. In this instance the AP is aligned between the maxillary lateral incisor and canine contact. If the patient is missing anterior teeth, the AP light can be aligned with the ala or corner of the nose. Some panoramic machines automatically adjust the AP position for the operator.

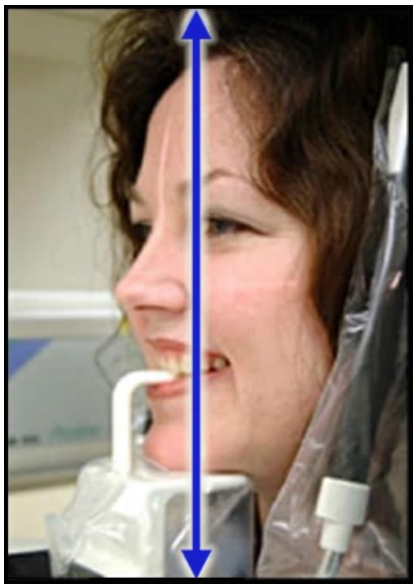


Figure 17. Anteroposterior Plane.

Pre-exposure Instructions

Because panoramic radiographic imaging requires patients to be stable for greater than 15 seconds during exposure, several additional instructions need to be provided to the patient. These include positioning of the tongue and lips and remaining still during the entire exposure cycle.

Image Projection

Panoramic radiography is based on the principles of tomography and slit radiography. Tomography is a body-sectioning technique involving the simultaneous movement of the x-ray tubehead and image receptor in opposite directions to produce an image at a depth of tissue. Slit radiography involves the acquisition of an image of a large structure by the scanning movement of a slit beam. These two processes produce a curved focal trough or image layer that theoretically corresponds to the average jaw shape. The anterior part of the layer is unavoidably narrower than the posterior part of the layer. Therefore, some patient's jaws will not exactly match the predetermined form of the image layer. Correct patient positioning is essential for optimal results. In general, image distortion occurs when structures are positioned anterior or labial (narrows and blurs), posterior or lingual (widens and blurs) or a combination thereof relative to the focal trough (Figures 18A-C).

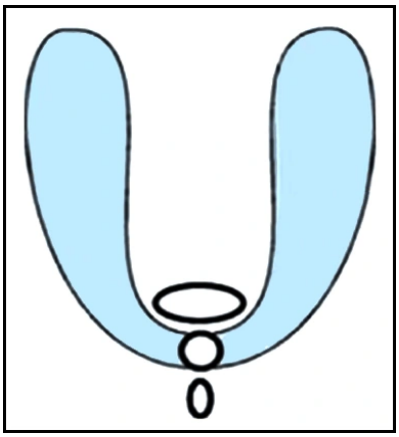


Figure 18A. Resultant curved image layer that corresponds to arch shape.

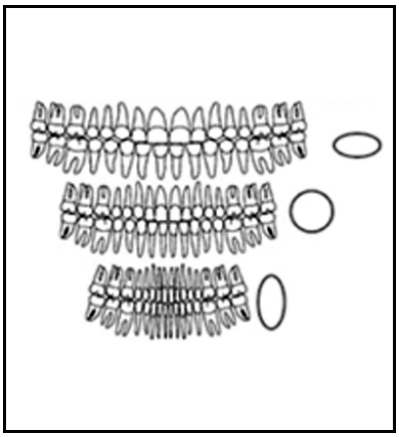


Figure 18B. Malpositioning relative to the focal trough alters structures most significantly in width.

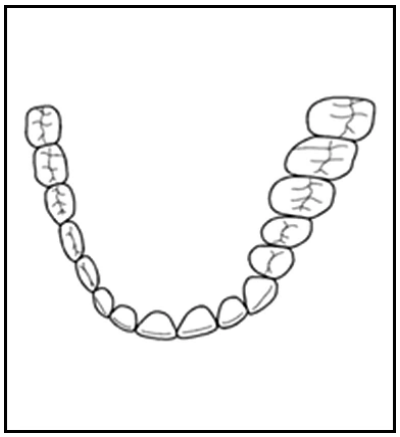


Figure 18C. Horizontal malpositioning results in one side appearing narrow and the other wider.

Slit Radiography

The side of the patient's dental arches closest to the receptor is recorded in focus while the side closest to the x-ray source is blurred out of focus (Figure 19). The x-ray source has a vertical slit aperture and directs the x-ray beam in a lingual to labial direction through the structures.

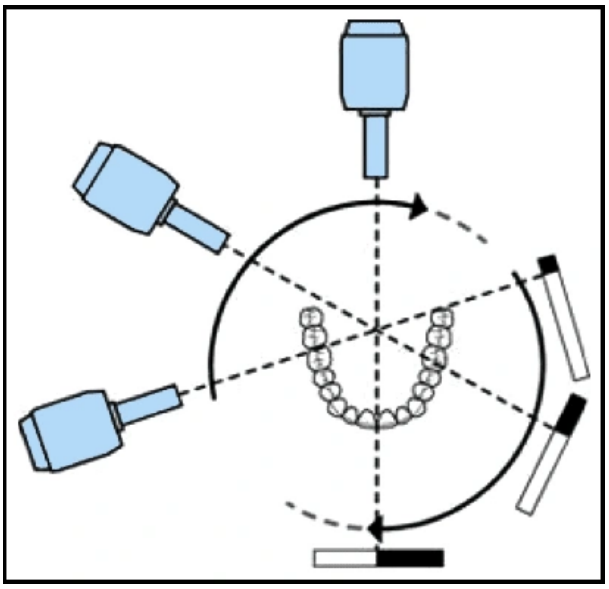


Figure 19. Schematic diagram of simple panoramic motion incorporating slit beam radiography and linked motion of x-ray tubehead and receptor.

Panoramic machines vary in style but operate according to the principles outlined above. Some models allow the patient to sit-down while in others the patient stands. The resulting image is uniformly magnified due to the long object-receptor distance with some premolar proximal contact overlapping. However, this technique produces good overall representations of the teeth and surrounding anatomical structures.

Operational Basics

Equipment

Panoramic x-ray machines are composed of an exposure control panel, a C-arm, and a patient positioning device.

- *Control panel and exposure switch* – The control panel typically contains the program selector, exposure selectors (milliamperage control, kilovoltage control), head positioning lights, temple bar operation, anteroposterior (AP) operation and other features. Control panels will vary among manufacturers as well as direct digital and plate/film-based machines. The complexity of the control panel increases with the incorporation of features such as multiple program options and automatic exposure control (AEC) features.

Figure 20. Digital Panoramic Unit Control Panels.
Source: 2009 Proline Panoramic XC, Panmeca.

Legend:
1 - Kilovoltage Display
2 - Milliamperage Display
3 - Program
4 - Patient Size → Set Exposure Factors
5 - Up and Down
6 - Temple Bars
7 - Anteroposterior Lights and Positioning
8 - Jaw Shape - Adjustable

- *C-arm (x-ray tubehead/receptor assembly)* – The relationship of the x-ray tubehead is fixed spatially to the receptor assembly by a fixed C-arm support. The panoramic x-ray tubehead is similar to an intraoral x-ray tubehead. However, unlike the intraoral tubehead, there is both pre- and post-patient linear collimation to provide a slit beam.

- *Patient Positioning Device* – The radiographer must be familiar with the operation of the patient positioning device as it is this apparatus that is used to position the patient's head into the focal trough of the machine. This device comprises a head holder and a chin rest/bite block. The chin rest/bite block is used to stabilize the patient's dentition in the anteroposterior direction whereas the head holder is used to stabilize the orientation of the patient's head in both the vertical and horizontal planes.

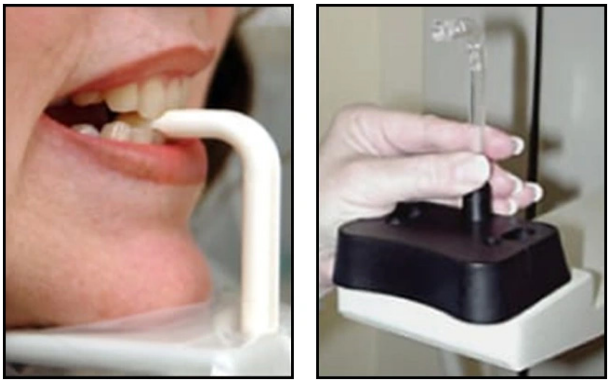


Figure 21. Patient Positioning Devices.

Steps in Taking a Panoramic Image

Procedural Steps

Table 2. Steps in Panoramic Imaging Procedure.

Unit Preparation

- Explain the procedure to the patient prior to the unit entry and positioning.
- Instruct patient to remove head and neck metallic objects and safely store them.
- Instruct patient to take out any intraoral protheses and safely store them.
- Place panoramic lead apron high in front and low in back.
- Have patient stand straight with erect spine and relaxed shoulders.

Patient Preparation

- Explain the procedure to the patient prior to the unit entry and positioning.
- Instruct patient to remove head and neck metallic objects and safely store them.
- Instruct patient to take out any intraoral protheses and safely store them.
- Place panoramic lead apron high in front and low in back.
- Have patient stand straight with erect spine and relaxed shoulders.

Patient Positioning

- Adjust machine height so that carriage clears the patient's shoulders.
- Instruct patient to step into the machine grabbing low on the handholds.
- Guide the patient's head between the open temple bars.
- Raise the bite piece so that the patient can bite edge-to-edge with the front teeth.
- If patient is edentulous, use cotton rolls to replace anterior teeth.
- Lower the bite piece until the patient's chin is resting on the chin rest.
- Close the temple bars and turn on the alignment lights.
- Facing the patient, align the midsagittal head plane perpendicular to the floor.
- From the side, align the Frankfort horizontal plane parallel to the floor.
- From the corner, align the anteroposterior plane with the ala of nose or machine specific landmark.

Post-exposure Instructions

- Instruct the patient to press the entire tongue against the roof of the mouth.
- Instruct the patient to close the lips around the bite piece.
- Instruct the patient to close their eyes to avoid tracking the machine movement.
- Let the patient know that the machine may brush their shoulders during procedure.
- Instruct the patient to hold completely still until the machine stops.

Dismissal Positioning

- Instruct the patient to release the bite piece.
- Instruct the patient to hold hand grips until they step back and are stable.

- Check the image for diagnostic quality before saving. Retake only if necessary.
- Remove the patient lead apron and hang properly.
- Return oral prostheses and head/neck metallic objects.
- Guide patient back to the operatory.
- Return to unit and complete follow-up infection control procedures.

Preparation

Before a patient can be positioned in the panoramic x-ray unit, it is important that both the machine and patient are prepared prior to exposure.

Machine Preparation

Set the program mode on the panoramic unit – Even the simplest panoramic units can be used in a variety of modes. It is important that the operator ensure that the correct mode is selected prior to patient exposure.

Set the exposure – For most panoramic units, patient exposure is adjusted by alteration of the kilovoltage (kVp) and milliamperage (mA). This adjustment should be based on the physical stature of the patient. Basic guidelines follow that assist the clinician in this decision-making process. While the operator should follow the general guidelines recommended by the manufacturer, consideration needs to be given to the patient size, thickness of tissues, presence of teeth and bone density characteristics. Patients that are considered above the norm in each of these characteristics would require an increase in the kVp and mA settings while patients below the norm would indicate a decrease. If the unit is manually adjusted, an exposure chart is available in the user's manual. For manually adjusted panoramic units it is necessary and mandated by law that an exposure chart be posted adjacent to the exposure control.

Table 3. Sample Exposure Chart.

Patient Size Category	Kilovoltage (kV)	Milliamperage (mA)
Child Patient ≤ 6 years old	62	5
Child Patient 7-12 years old	64	8
Adult Female/Small Male Patient	66	9
Adult Male Patient	68	11
Large Adult Male Patient	70	12
Additional Factors to Consider		
Obese, Large-boned, Dense Bone	Increase kV	Increase mA
Frail, Small-boned, Edentulous	Decrease kV	Decrease mA

Source: 2009 Proline Panoramic XC, Planmeca

Assemble and insert bite block – Bite blocks can be either disposable or designed to be reused. Disposable bite blocks are usually made of a material that is unable to be autoclaved. Reusable bite blocks are either chemically sterilized or autoclavable.

Position machine slightly higher than patient's chin – Prior to patient preparation the approximate height of the patient should be determined, and the chin rest adjusted to be slightly higher than the patient's chin. When the patient attempts to bite in the grooves of the bite block, they must, therefore, raise their head. This helps to keep the spine straight. It is easier to adjust the vertical placement of the patient's head downwards from this position than to force the head up with the action of the panoramic unit.

Patient Preparation

Remove metallic objects – Before patient positioning and x-ray exposure, it is necessary to remove all metallic objects in the head and neck region including eyeglasses, facial jewelry and especially necklaces, earrings, tongue rings, prosthetic devices that may incorporate metals such as hearing aids and finally the patient's napkin ("bib") chain. These items are capable of producing artifacts on the image both directly and indirectly, such as "ghost" projection or secondary images all potentially interfering with diagnosis.

Although not required by law, many practices post signs adjacent to the panoramic unit as a reminder to both operators and patients for the need to remove such items prior to exposure.

Place the lead apron on the patient – The use of the lead apron on dental patients is regulated by state statute and may be mandatory.

Lead aprons are available in many designs including the "poncho" and "coat", however regardless of the type, the apron should be raised at the front of the patient rather than the raised over the shoulder. In this manner the lead apron affords greatest protection to the sternum, thyroid, and gonads.

Patient Positioning and Exposure

Step into the machine – Instruct the patient to stand behind the machine with a straight, erect spine with the shoulders down. The clinician should adjust the machine just slightly higher than the patient's chin. Instruct the patient to step forward, placing their hands low on the hand holds. Make sure that the machine will clear the shoulders bilaterally.

Have the patient shuffle forward – Because of the design of the panoramic unit, the natural tendency for patients when asked to put their head in the head holder is to thrust it forward, slumping over. This slumped position produces a greater depth of soft tissue of the neck with an increase in midline opacity on the resultant image.

Figure 22. Correct head position but with neck extended.

Figure 23. Correct head and neck position after "panoramic shuffle" with straightening of the spine.

Bite in the bite block – While this direction may seem simple, most patients will require some guidance as to what to do. Raise the bite block so that the patient can get their anterior teeth in the groove end-to-end, then lower the pin so the chin is seated on the chin rest. The overriding principle is that the incisal edges of the anterior teeth must be stabilized within the grooves. The grooves are coincident with the middle plane of the anterior portion of the focal trough and is the mechanism by which the anteroposterior position of the head is stabilized. If the patient is edentulous, place a cotton roll on each side of the bite block and secure with an orthodontic elastic or rubber band. The elastic can be placed to coincide with the bite block groove so that the patient knows where to place their ridges.

Adjust head position horizontally – Correct positioning with respect to the horizontal plane minimizes differential left or right distortion and can be accomplished by visual assessment of the tilt and rotation of the patient's head from behind. In most panoramic units, this is further facilitated with the use of a midsagittal reference light or line superimposed on the frontal head support to assist the clinician with horizontal head positioning. The temple bars should be put in place to help maintain the head position. The midsagittal or horizontal head plane is best evaluated by looking down the light directly at the patient's midline. If the machine utilizes a mirror system, the patient is asked to assist in head positioning by looking at their reflection in the mirror and adjusting the position of their head such that the line equally divides their face right to left.

Adjust head vertically – Most typically, the Frankfort horizontal plane or the occlusal plane is used to set the vertical (up/down) head plane in panoramic imaging. Refer to the manufacturer's instructions for the specific reference line for the panoramic unit being used.

While the teeth are engaged in the bite block end-to-end, the panoramic unit should be raised or lowered such that the lateral reference line referred to in the manufacturer's instructions is parallel to an external reference plane. This external reference plane can be the floor or is located on the head holding device. Many panoramic units use adjustable light beams to assist the operator in orientating the patient's head. It is best to evaluate the vertical head plane from the side or by looking at the patient's profile. The forehead and chin should be in the same vertical plane. Many units will also have a forehead support to secure the patient's head position in the vertical plane.

Figure 24. Panoramic unit (PC1000, Panoramic Corp.) with external reference guides on lateral head holders.

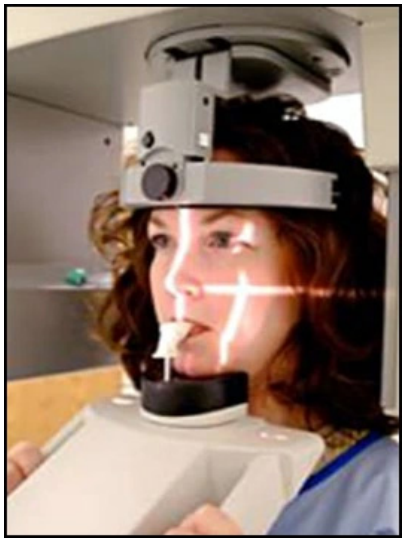


Figure 25. Panoramic unit (OP100, Instrumentarium Imaging) with light beam reference guides projected onto the patient's face.

Adjust head position anteroposteriorly - The anteroposterior (AP) plane is aligned with a specific landmark that varies among panoramic machines. It is important to know the specific landmark recommended by the manufacturer. The AP position is aligned by moving the chin rest forward or back until it is aligned with the landmark. Many machines align the AP between the maxillary lateral incisor and canine contact on the maxilla or centered over the canine tooth. If the patient is missing anterior teeth, the AP light can be aligned with the ala or corner of the nose. The AP position is best evaluated by looking down the light from the corner of the arch. Some panoramic machines automatically adjust the AP position for the operator.

Ask the patient to close lips and hold tongue on the roof of their mouth – During the previous stages, the patient's facial musculature will tend to assume a relaxed position. This results in the lips around the bite block being open and the tongue dropping to the floor of the mouth. Immediately prior to exposure the patient should be instructed to close their lips and press their entire tongue against the roof of their mouth and keep it there throughout the exposure of the patient.

Figure 26.

According to Rushton et al.,[13] while failure of the patient to place their tongue in the correct position is the most common technical fault (71.9%) it rarely results in an image being unacceptable (0.1%). Several more recent studies have documented that the tongue placement error continues to persist as the most common whether digital or film-based systems are utilized.[14-16]

Exposure and patient dismissal – According to law, when a panoramic exposure is made on a patient, the operator *must*:

1) be positioned to observe the patient throughout the entire exposure
2) be either 2 meters (approximately 6 feet) from the patient or if closer than 2 meters, behind a barrier.

Immediately prior to exposure the patient should be informed that the panoramic unit will move in front of them and take approximately 20 seconds to complete the rotation. The patient should also be reminded to keep their lips together and press the tongue against the roof of their mouth for the entire exposure. It is helpful to instruct the patient to close their eyes as well so that they do not follow the movement of the receptor. If the patient tracks receptor movement, an error in the midsagittal plane will occur.

Patient exposure is achieved by depressing the exposure button and keeping it depressed throughout the entire rotation of the panoramic unit until it comes to a complete stop. The exposure control is a "Deadman" switch. This means that release of the button will terminate not only the exposure of the patient to x-radiation but the rotational motion. Exposure should be terminated if the patient moves markedly at the beginning of the exposure. This can be either due to the spontaneous patient motion (e.g. cough, sneeze) or due to shoulder interference with the rotational motion of the C-arm.

After exposure, most machines will release the temple bars/supports immediately. The clinician should instruct the patient to release the bite block and ask the patient to slowly back away from the head rest. Only after the radiographic image has been determined to be diagnostically acceptable should the patient be dismissed or escorted back to the operatory.

Image Evaluation

The diagnostic criteria for a panoramic image are outlined in Table 4.

Table 4. Panoramic Diagnostic Criteria.

- Entire maxilla and temporomandibular joints recorded.
- Symmetrical display of the structures right to left.
- Slight smile or downward curve of the occlusal plane.
- Good representation of the teeth with minimal under or over magnification.
- Tongue in place against the palate with the lips closed.
- Minimal or no cervical spine shadow visible.
- Overlapping of posterior teeth, particularly the premoloars, is expected.
- Acceptable image density and contrast.
- Free of patient preparation, technical and exposure errors.

An optimal panoramic radiograph should be free from errors related to patient preparation, technique, or exposure.

In reality, many panoramic images are not optimal and present minor but acceptable errors.

However, there are certain specific ***critical errors*** that result in images that fail to fulfill the criteria for an acceptable panoramic image. These errors are critical because they usually necessitate re-exposure of the patient.

The principle technical criterion for acceptance of a panoramic radiographic image is that it should image all the structures of the maxillofacial region. If any of the structures are not present, either because it is not covered or obscured, then it

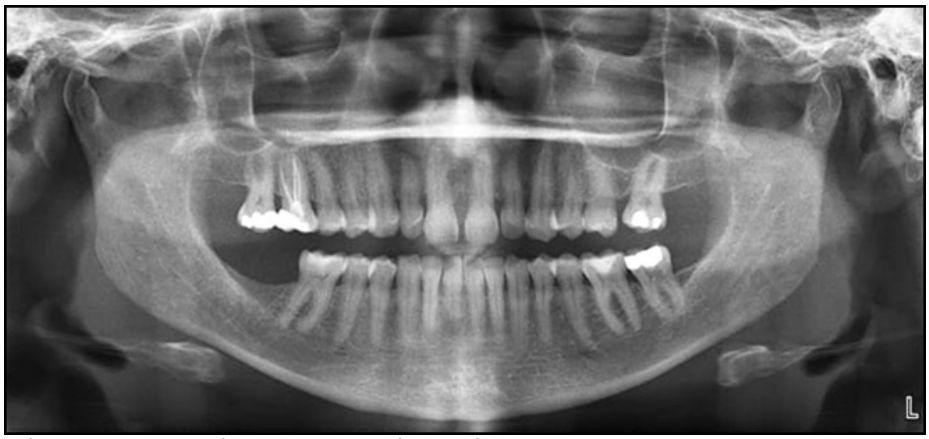


Figure 27. Optimal Panoramic Radiograph.

Figure 28. Panoramic with acceptable errors.
Patient's head is positioned slightly downward, and a thin palatoglossal airspace is present. These errors do not interfere with the overall diagnostic acceptability and the image does not require a retake.

should be retaken. It should be remembered that the patient pays for the interpretation and subsequent diagnosis generated from the panoramic image and not the procedure itself.

Specific ***exclusionary criteria*** include the inability to visualize any of the following either due to the structure not being imaged on the receptor or obstruction of the structure from view:

- Condyle of the temporomandibular joint (TMJ)
- Mandibular/maxillary anterior region
- Mandibular ramus

Figure 29 demonstrates three of the most common reasons for retakes – neither the condyle of the TMJ, the mandibular anterior region nor the mandibular ramus are visualized on this radiographic image. In this particular case it is because the patient's head is tilted too far down during exposure.

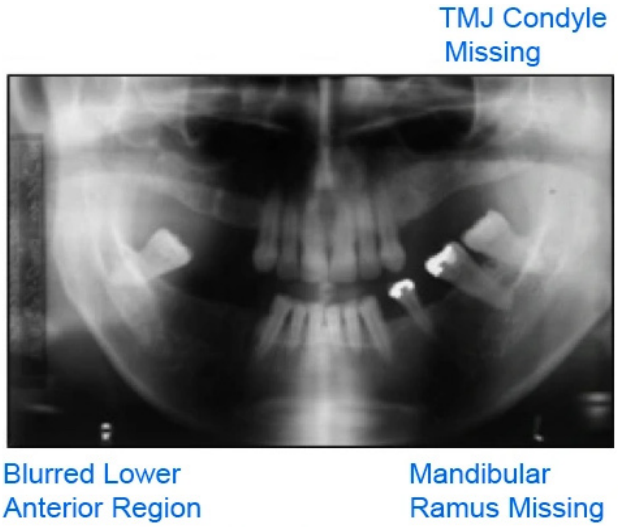


Figure 29.

Figure 30 demonstrates three further reasons for retakes: poor visualization of the maxillary anterior region, coverage of structures due to the presence of ghost images and/or labels. In this particular case the patient is positioned too far backward and has their head tilted too far up (as evidenced by the reverse or frown occlusal plane). These positioning errors place the maxillary anterior region out of the focal trough and produces excessive ghosting of the amalgam restorations of the opposite side.

Features of an Optimal Panoramic Radiograph

There are two general features that distinguish this panoramic from a poor one – they are adequate exposure and correct anatomic representation.

Adequate exposure – An assessment of adequate exposure implies that there is adequate density (overall darkness) and contrast (differences in density) to recognize anatomic features.

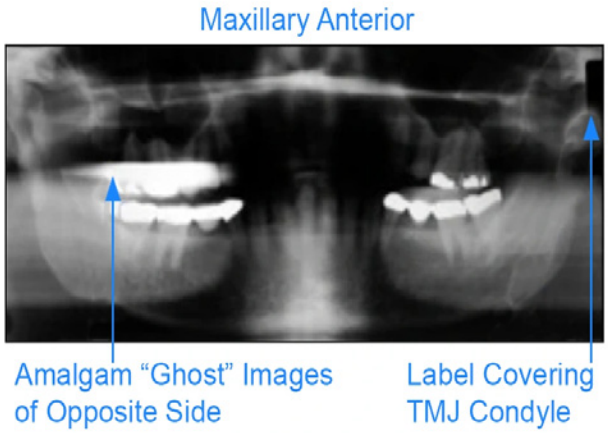


Figure 30.

Figure 31. Example of an excellent edentulous panoramic radiograph with adequate exposure and correct anatomic representation.

- **Density** - The ideal density should be such that structures are not obstructed by areas of darkness i.e. areas of "burn out" or areas that are too light i.e. areas of "white out". Visually this can be assessed by looking at the mandibular parasymphyseal area and region associated with the apices of the maxillary teeth. In the maxilla this is most evident when the tongue is not held in position during panoramic exposure. ***Excessive or inadequate density*** can lead to failure to detect features such as unerupted and impacted teeth or even pathology. A dark or high-density image is usually caused by overestimation of the patient's overall size, stature, and bone density while a light or low-density image is usually caused by underestimation of the patient's overall size, stature, and bone density.

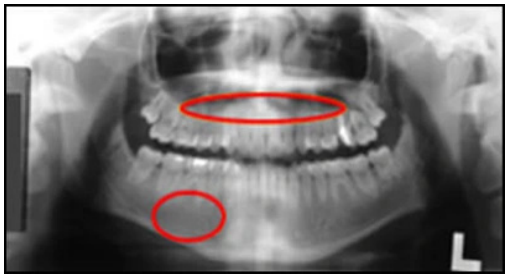


Figure 32. Regions on a panoramic radiograph to look at to determine adequate density.

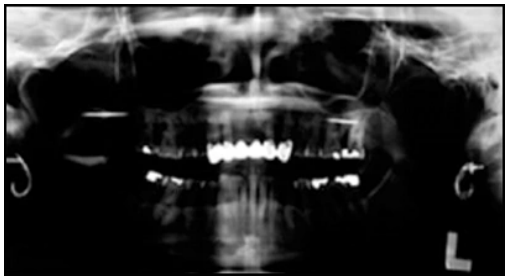


Figure 33. Example of an overexposed panoramic radiograph.

Example of an overexposed panoramic image:

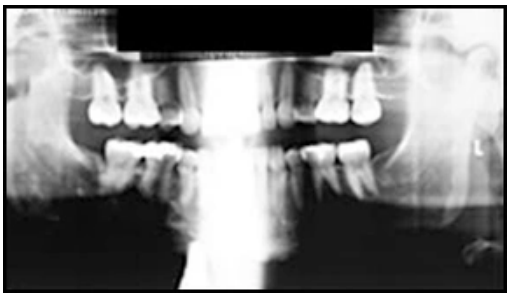


Figure 34A.

Figure 34B.

Images demonstrating how excessive exposure can lead to failure to detect pathologic features. The image on the right is a digitally enhanced version of the left overexposed panoramic radiograph and clearly demonstrates the appearance of a radiolucent region causing expansion and thinning of the inferior cortex of the right mandible – features that were not evident on the original.

Example of an underexposed panoramic image:

Figure 35A.

Figure 35B.

Images demonstrating how inadequate exposure can lead to failure to detect pathologic features. This image on the right is a digitally enhanced version and clearly demonstrates the appearance of an impacted mandibular right third molar that was not readily apparent on the original (left). This enhancement also clearly demonstrates a large pericoronal lesion that involves the right second mandibular molar.

- **Contrast** – The second element of adequate exposure assessment is contrast. This can best be assessed by determining if the interface between the enamel and the dentine can be seen, usually in the molar region. The dentinoenamel junction (DEJ) should be apparent.

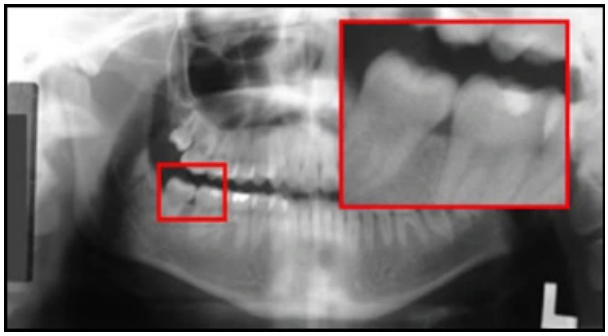


Figure 36. Assessment of contrast in panoramic radiograph.

Anatomically representative – A panoramic should be a good representation of the maxillofacial structures that it images. This means that there is adequate coverage of the osseous structures and that they are represented with some degree of accuracy. To determine correct anatomic representation, a visual assessment of the panoramic radiograph should be performed for accuracy of both anatomic structures and the dentition.

- Anatomic assessment – Several features can be used to determine anatomic accuracy including:
  - The condyles are on image – Usually in the upper outer sextant and at same level.
  - Palate and ghost images of palate should be above the apices of the maxillary teeth, running through the lower portion of the maxillary sinus.
  - Ramus width should be similar on both left and right sides.

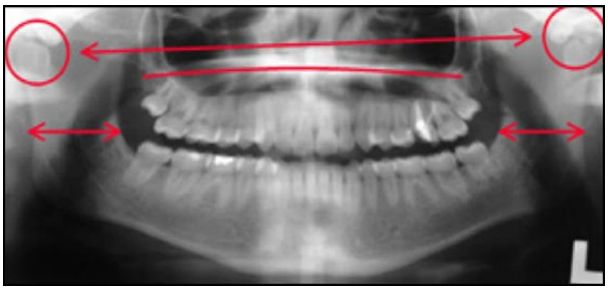


Figure 37. Anatomic features to be compared in the assessment of panoramic anatomic accuracy.

Panoramic anatomy – A reference for anatomic structures commonly observed on panoramic diagram appears below. Many of these structures are mentioned in the prior text and in the subsequent discussion of common errors.

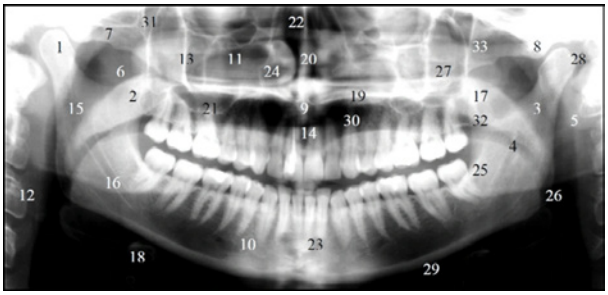


Figure 38.

1. Mandibular Condyle	12. Cervical Vertebra	23. Genial Tubercles
2. Coronoid Process	13. Zygomatic Process	24. Nasal Concha
3. Nasopharyngeal Airspace	14. Incisive Foramen	25. External Oblique Ridge
4. Oropharyngeal Airspace	15. Mandibular Foramen	26. Angle of the Mandible
5. Styloid Process	16. Mandibular Canal Space	27. Zygomatic Bone
6. Lateral Pterygoid Plate	17. Soft Palate	28. Glenoid Fossa
7. Zygomatic Arch	18. Hyoid Bone	29. Inferior Border of the Mandible
8. Articular Eminence	19. Hard Palate	30. Palatoglossal Airspace
9. Anterior Nasal Spine	20. Nasal Septum	31. Pterygomaxillary Fissure
10. Mental Foramen	21. Maxillary Sinus Floor	32. Maxillary Tuberosity
11. Infraorbital Canal	22. Nasal Fossa	33. Zygomaticotemporal Suture

Features of the Dentition – Several visual features of the dentition can be used to assess whether the teeth, particularly the anterior teeth are positioned correctly within the focal trough:

- No or slight upward curve of teeth
- No tooth size discrepancy on left or right side
- Anterior teeth in focus (see pulp canal clearly)
- Anterior teeth shape "normal"
- Not too narrow or too wide
- Premolars will always overlap due to inherent x-ray beam projection to the arch of the teeth in this region.

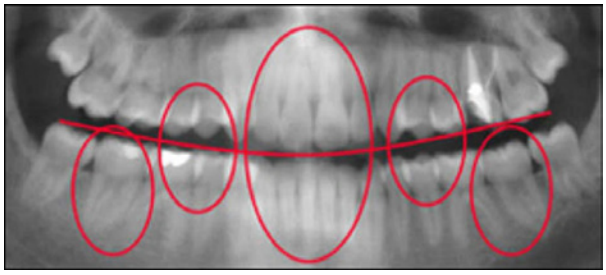


Figure 39. Features of the dentition to be compared in the assessment of panoramic anatomic accuracy.

Identifying Panoramic Errors

Panoramic radiographic imaging is technique sensitive. The clinician must address all aspects of machine and patient preparation, patient positioning, patient instruction and exposure to produce a quality image. A number of authors indicate that the quality of panoramic radiographic images taken either in an institutional setting,[19-21,18-20] in general dental practice or submitted to third party insurance providers[17,18] is low. In most instances, a low percentage of panoramic images were found to be error free and many panoramic images demonstrated multiple errors.[15-22]

In 2014, Rondon et al.[20] conducted a review of the literature to determine the most common types of patient positioning errors. The most common positioning errors that resulted in a retake or repeated panoramic radiographic examination were respectively:

1. Head positioned too far forward,
2. Head turned right or left,
3. Head tilted down, and
4. Head positioned too far backward.[19]

Asha et al. conducted a review of 560 digital panoramic radiographs in 2018.[21] They found the most common errors in order by percentage of occurrence were:

1. Chin tipped too high,
2. Head twisted,
3. Chin tipped too low,
4. Head too far backward,
5. Tongue not on palate,
6. Slump spine, and
7. Head too far forward.[21]

Table 5. Panoramic Patient Positioning Errors.

Rondon et al. 2014
1. AP Head Plane - Too Far Forward
2. Horizontal Head Plane - Turned
3. Vertical Head Plane - Chin Down
4. AP Head Plane - Too Far Back
Asha et al. 2018
1. Vertical Head Plane - Chin Up
2. Horizontal Head Plane - Twisted
3. Vertical Head Plane - Chin Down
4. AP Head Plane - Too Far Backward
5. Tongue Not on Palate
6. Spine Slumped
7. AP Head Plane - Too Far Forward

Stepwise Approach to Panoramic Technique Assessment

Panoramic errors result in image presentations that may be due to patient preparation, machine preparation, patient positioning, tissue projection, patient movement, shoulder interference or a combination thereof.

Technique Errors

Technique errors can result from difficulties encountered from each of the three stages in panoramic technique:

Patient Preparation

The features of these errors on radiographs are characteristic and are therefore usually readily self-diagnostic.

- **Metallic artifacts** – The most common patient preparation error is failure to remove metallic or radiodense objects – This causes two problems:
  - First, they produce a radiopaque outline of themselves, usually providing a telltale indication of the error.
  - Second, they may produce so-called "ghost images." Ghost imaging is a normal component of the panoramic projection and occurs when an object is penetrated twice by the x-ray beam. Structures or objects that are located posterior to (behind) the center of rotation and the x-ray source tend to be ghosted onto the contralateral side of the image. Ghost images have specific recognizable characteristics that are viewable on the panoramic image.

Table 6. Ghost Characteristics.

- The ghost image has the same general shape of the original object but does not produce a mirror image.
- The ghost image appears on the opposite side of the panoramic image compared to the original object.
- The ghost image appears in a higher position on the image than the original object.
- The ghost image appears magnified and unsharp (/blurred) more in the vertical plane compared to the original object.

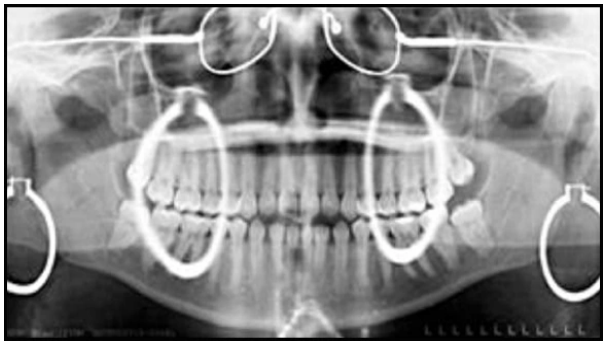


Figure 40. This image illustrates the telltale signs of leaving several metallic objects on the patient – earrings, glasses and a neck chain. Note the ghosts of the earrings.

- An example of this occurring to normal anatomic structures is the angle of the mandible projected to the other side or the two lines of the palate.

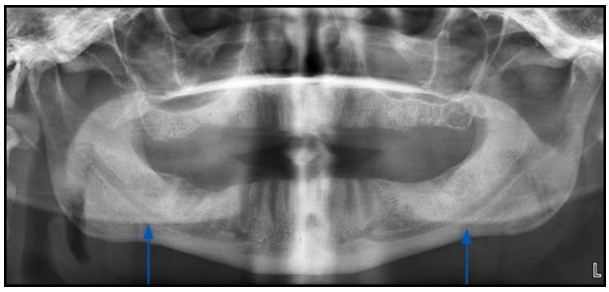


Figure 41. Ghost of the Angle of the Mandible.

- **Lead apron** – The second most common patient preparation error is incorrect placement of the lead apron. This produces a characteristic radiopaque domed or wedge-shaped artifact that also obscures diagnostic information associated with the mandible. Correct positioning of the lead apron involves ensuring that the apron is not placed too high up the patients back prior to exposure.

Figure 42. Example of lead apron artifacts.

- **Thyroid collar** – Because of the nature of the projection beam in panoramic radiography, in effect coming up and over the shoulder of the patient, thyroid collars are not to be used. If the thyroid collar is placed on the patient it produces a characteristic appearance bilaterally – a radiopaque cone shaped artifact centrally located which obscures diagnostic information, particularly in the mandible.

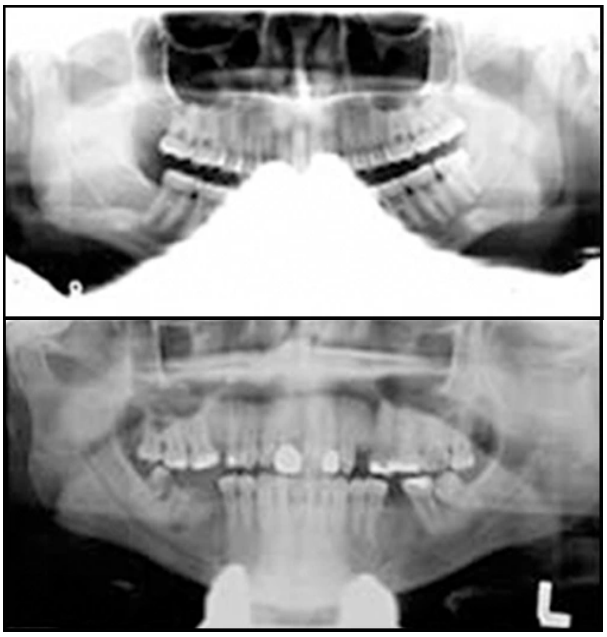


Figure 43. Examples of thyroid collar artifact.

Machine Preparation

The second category of errors involves factors associated with the panoramic equipment that may lead to poor image formation.

- **Incorrect Exposure** – The most common machine variable error occurs with selection of the incorrect exposure setting – usually kVp. Kilovoltage settings that are too high produce dark images while low kVp settings result in light images. Correction of this type of error usually involves a retake at a kVp that is either 5% above, in the case of an underexposed radiograph, or 5% below, in the case of an overexposed radiograph, the initial setting.

  In the case of digital radiography, only overexposures can be corrected with use of image software. A severely underexposed image does not contain all of the information in the first place and density manipulation will not improve the image quality.

  The two examples here show the effect of overexposure (Figure 44) and underexposure (Figure 45) on the panoramic image.

Figure 44. High Density Image.

Figure 45. Low Density Image.
The two examples here show the effect of overexposure (top) and underexposure (bottom) on the panoramic image.

- **Incomplete exposure** – Another error occurs principally with panoramic units that use a flexible cassette attached to a rotating drum. If the drum is not re-aligned at the correct start position after attachment of the cassette, only a partial image will be obtained. In addition, a partial image can be produced if the operator lets go of the exposure button prior to completion of the entire exposure cycle or if shoulder contact stops machine rotation.

- **Incorrect program selection** – An error that may occur principally with panoramic units that allow various program options, is failure to change the program after the previous patient. This results in exposure of the patient using the previous program choice.

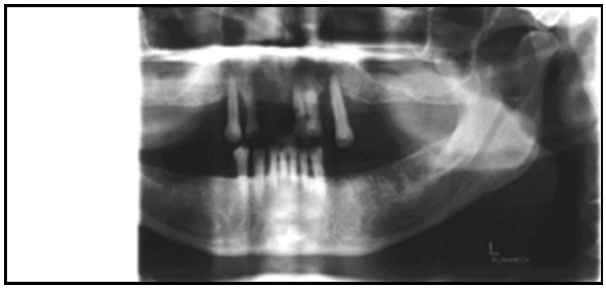


Figure 46.

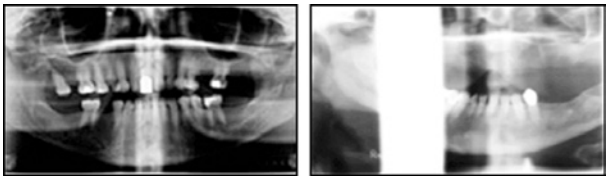


Figure 47. The two examples above show the effect of incorrect program selection. The image on the left image resulted from using a child exposure program, limiting the field of exposure posteriorly. The image on the right is due to the use of an orthogonal program segmenting the anterior and posterior dentition without coverage of the ramus and TMJ.

Patient Positioning

The second component of technique error analysis is the determination of patient positioning errors. This is of critical importance because even small patient positioning errors can produce effects that can obscure areas of the image and result in the loss of diagnostic information.

Technique errors can be easily recognized by careful analysis of the position, relationship of structures, unsharpness and distortion in a panoramic radiograph. The visual effects of incorrect patient positioning on the image may be described according to whether they affect anatomic representation or features of the dentition.

Patient Positioning Errors

There are three sub-categories of errors that result from poor patient positioning technique:

1. Incorrect head orientation
2. Tissue projection errors
3. Shoulder-Receptor/X-ray Head Interference

Incorrect Head Orientation

There are three planes in which the patient's head may be positioned incorrectly: 1) Horizontal, 2) Vertical and 3) Anteroposterior. Incorrect positioning in each plane produces characteristic effects. Of course, there is the possibility of multiple errors in more than one plane – this will produce multiple and sometimes compounding effects and, in this instance, have are referred to as "compound" errors. The analysis of positioning errors therefore involves stepwise recognition of the radiographic features associated with each planar discrepancy.

Horizontal plane discrepancies – Alter the position of the teeth and jaws on one side relative to the path of the effective rotation center and x-ray beam projection. The two feasible options are that the patient is a.) twisted (rotated) with respect to the machine, or b.) that their head is tilted. Both result because the midsagittal plane of the patient is not correctly aligned at the time of exposure. This can occur if the patient "follows" the receptor during exposure and move off-center.

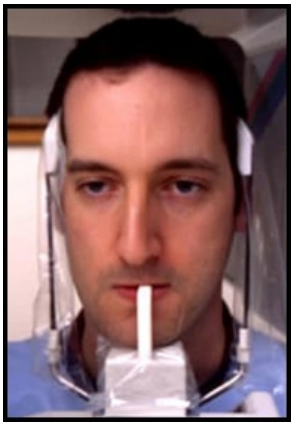


Figure 48. Rotated/ Twisted/Turned.

Figure 49. Tilted/Canted.

- This error can be prevented by ensuring the midsagittal reference line of the panoramic unit coincides with the patient's midline and that this line is perpendicular to the floor. Prevention of patient movement can be facilitated by adjustment of the lateral head supports to stabilize the patient to prevent movement during exposure.

- The principal effect of mal-positioning the patient is to offset more lateral and posterior structures, like the posterior dentition and ramus, with respect to the focal trough and x-ray beam projection.

Twisting – The most obvious image effects from the patient head "twisting" within the machine are anatomic. Most noticeably:

1. The width of ramus on one side reduces (closer to the receptor) and becomes closer to the spine.
2. The width of the ramus on other side increases (farther away from the receptor) and is further away from the spine – and may also be projected off the image.
3. The nasal conchae on the side opposite the twisting are more pronounced.
4. The maxillary sinus and nasal fossa of the same side as the twisting become more noticeable.

While the anterior teeth remain normal, there are two secondary effects on the dentition:

1. The first is that tooth size increases posteriorly on the side opposite to the direction of head tilt and,
2. Secondly, there appears to be increased overlapping of contacts on the opposite side of the tilt.

Tilting – The principal effect of tilting the patient is to create artifacts in the dentition and ramus superoinferiorly. The most obvious image effects are also anatomic. Most noticeably:

1. The lower border of the mandible slopes markedly on the side to which the head is tilted.
2. The mandible also appears elongated and tilted up.

The effects of tilting on the dentition include:

1. A reduction in the size of the teeth on the tilted side.
2. A greater overlap of the teeth on the opposite side.
3. Canting (sloping) of the occlusal plane towards the tilted side.

Vertical plane discrepancies – Alter the relative position of the occlusal plane of the teeth and condyles of the mandible. The viable options are that the patient's chin positioned too far up, too far down or that it

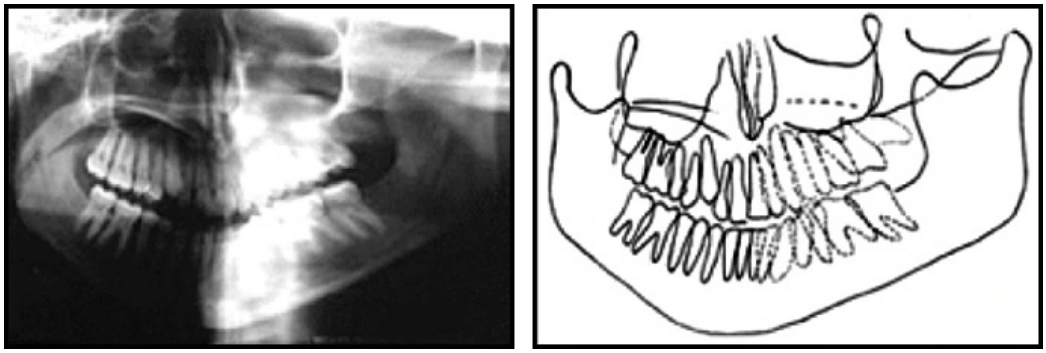


Figure 50. Panoramic radiograph (schematic on right) demonstrating the effects of twisting – Elongation of left mandible, reduction in size of teeth on opposite side, occlusal plane canting and pronounced tooth overlap on the same side.

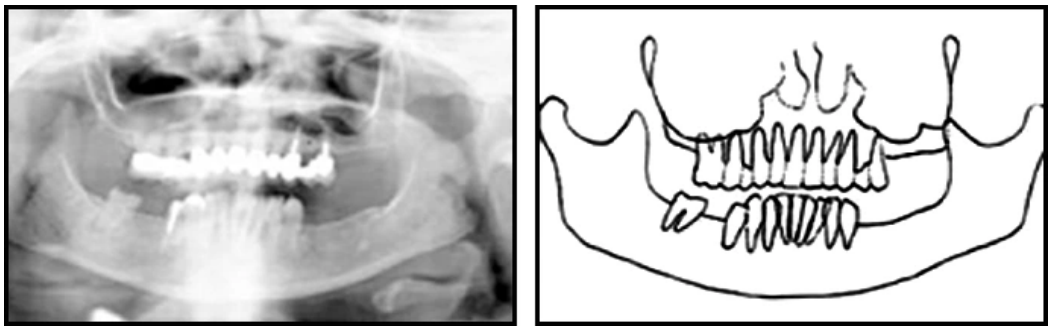


Figure 51. Panoramic radiograph (schematic on right) demonstrating the effects of tilting.

is not positioned on the chin rest (when this is used to position the patient). Vertical errors occur when the patient's head is incorrectly positioned superiorly inferiorly in the machine. The instructions in the manufacturer's manual may vary in which plane is used to adjust the patient's head up or down. Prevention of this error can be accomplished by ensuring that the patient's horizontal reference line is parallel to the floor or the lateral reference markers.

- Head/chin tilted too high – The first possibility is that the patient's head is positioned too high or tilted up.

Figure 52. Head/Chin Up.

1. Most noticeably, this produces a frown configuration of the occlusal plane.
2. The hard palate is superimposed over the maxillary teeth apices.
3. The TMJs are pushed posteriorly and in many cases are projected off the sides of the image.
4. The nasal cavity and other superior structures are blurred and out of focus.
5. The maxillary anterior teeth may appear elongated and fuzzy.

- **Head/chin tilted too low** – The second possibility is that the patient's head is positioned tilted too far down. The principal effect of tilting the chin down is to position more of the maxillae into the focal trough, align the maxillary teeth and to bring less of the lower anterior mandibular area into the focal trough. The anatomic effects of positioning the head too far down can be severe and may necessitate retaking the radiograph.

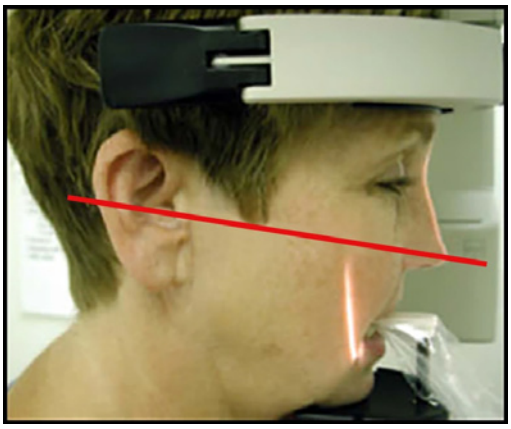


Figure 54.

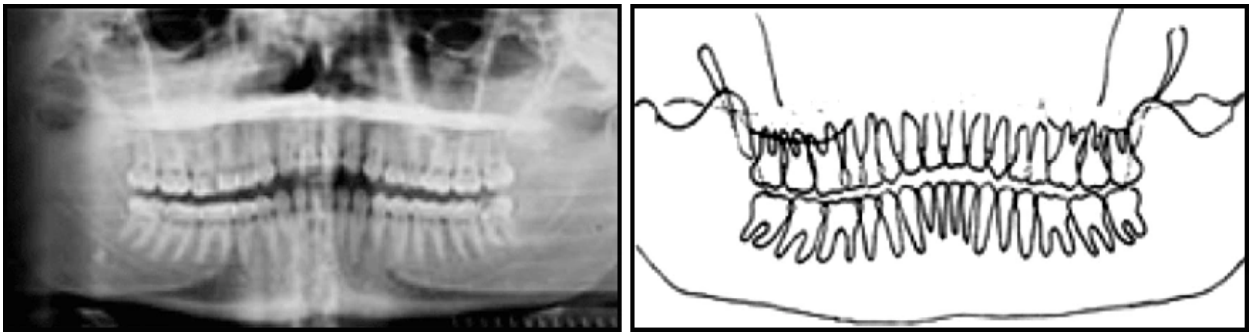


Figure 53. Panoramic radiograph (schematic on right) demonstrating the effects of positioning the head too far up.

1. Most noticeably, this produces a grin or "Jack-O-Lantern" configuration of the occlusal plane.
2. The TMJs are positioned higher and in many cases are projected off the top of the image.
3. The hyoid bone comes into the doubling diamond and forms a single widened line. The hyoid may superimpose over the lower border of the mandible.
4. The anterior mandible is usually widened and out of focus.
5. The mandibular anterior teeth may display pronounced foreshortening and appear out of focus.

- **Chin not on chin rest** – The third possibility is that the patient's chin is lifted from the chin rest. This is usually because the initial height of the machine is lower than the height required for the patient. Often a patient will stoop to enter a panoramic machine but once they are positioned and immediately before exposure will straighten themselves up.

The main visual effect of the chin being lifted from the chin rest is to create an image with a shift of anatomic structures superiorly. This may result in the top of the sinus and the condyles being cut off.

Anterioroposterior plane discrepancies – Alter the position of the teeth, especially the anterior teeth in the focal trough. The two practical options are that the patient is positioned either too far forward or too far backward.

Too far forward – Anterior positioning of the patient too far forward occurs either due to patient slipping forward, sucking the bite block, or not using a bite block.

Prevention of this error first necessitates that a bite block is used; secondly it requires that the patient's anterior teeth be placed in an end-to-end position in the bite block. Prevention of subsequent patient movement can be aided by adjustment of the forehead support, when available, to prevent the patient from sliding forward.

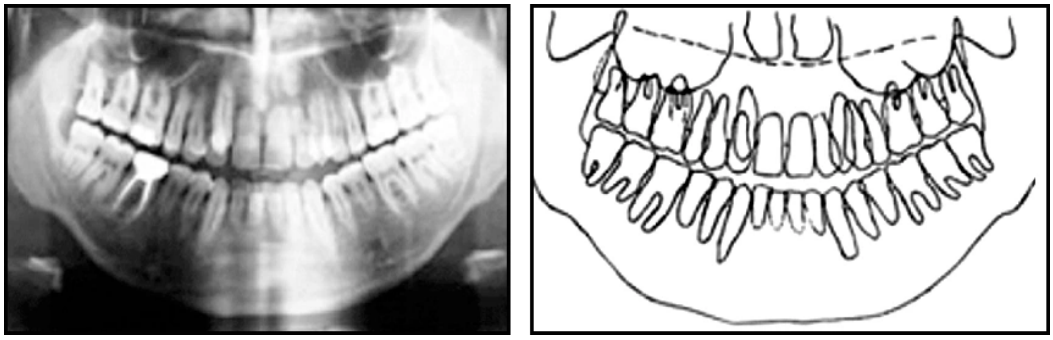


Figure 55. Panoramic radiograph (schematic on right) demonstrating the effects of positioning the head too far down.

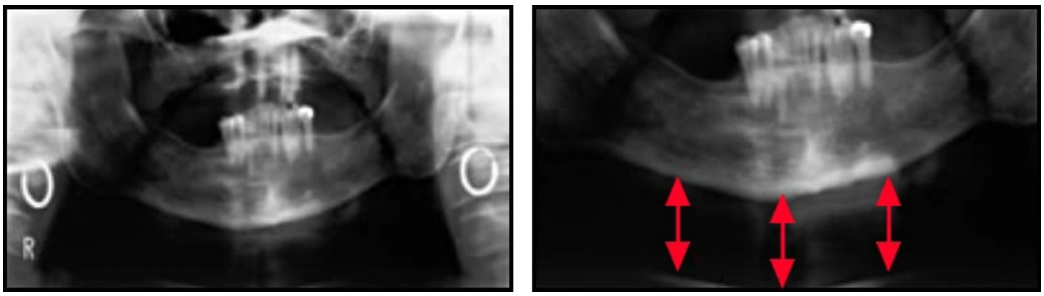


Figure 56. Panoramic radiograph (cropped and zoomed on right) demonstrating the effects of positioning the head off the chin rest. Note that in addition the patient is positioned too far forward.

Figure 57.

The effect of positioning the patient too far forward is to position structures that are normally within the focal trough, like the anterior dentition, further anteriorly and out of focus and to bring more posterior structures, like the spine, nasal fossa, and maxillary sinus into the focal trough.

1. Most noticeably, spine is superimposed over the ramus bilaterally.
2. The anterior teeth are narrowed in width on both arches and out of focus.
3. Severe overlapping of the teeth, particularly the premolars.

Prevention of this error, as with anterior positioning errors, necessitates that a bite block is used; secondly it requires that the patient's anterior teeth be placed in an end-to-end position in the bite block. Instances such as trismus or when a patient's jaws are wired together, the clinician can use the bitepiece to measure the approximate distance to position the patient on the chin rest.

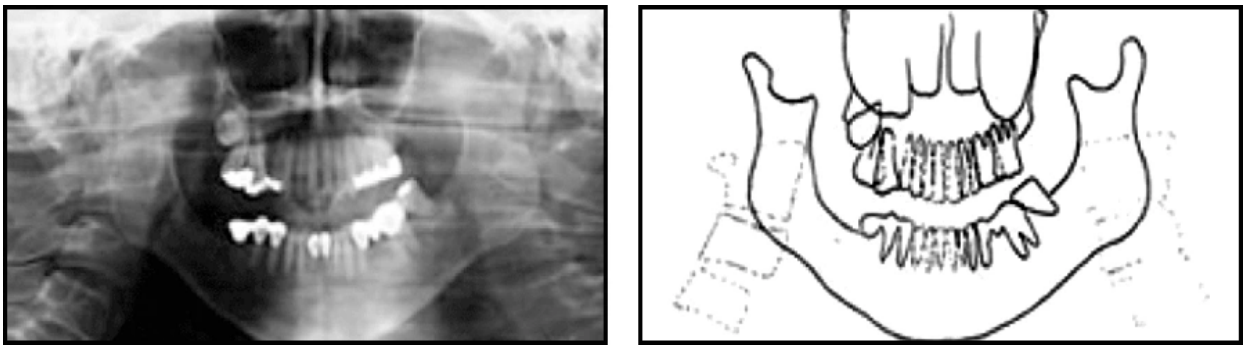


Figure 58. Panoramic radiograph (schematic on right) demonstrating visual effects on image with patient's head positioned too far forward during exposure: Spine superimposed over the ramus area, nasal fossa and maxillary sinus become clearly evident. Effects on the dentition however are the most noticeable with narrowing and blurring of the anterior teeth.

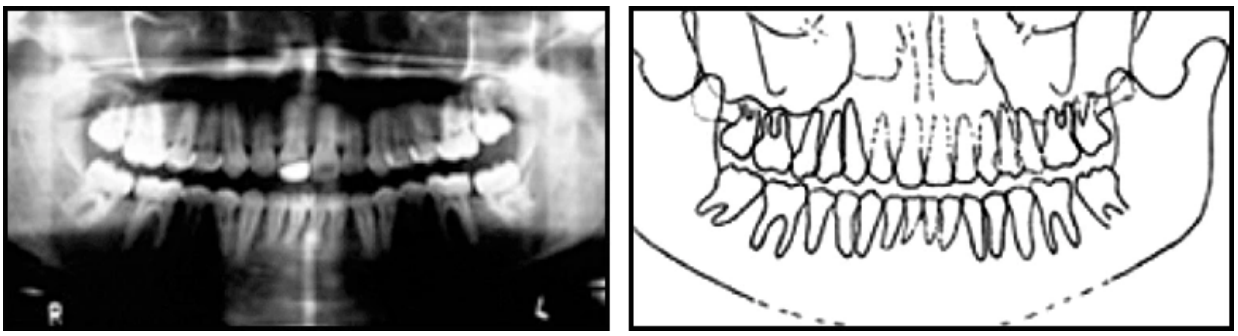


Figure 59. Panoramic radiograph (schematic on right) showing effects of positioning the patient's head too far back – widening of the entire image, loss of the posterior ramus of the mandible (right), accentuated ghosting of the mandible, and blurring of the turbinates across the sinus. Note the obvious effects on the dentition with pronounced widening of the anterior teeth.

Table 7. Patient Positioning Error Summary.

Panoramic Patient Positioning Errors		
Error Type	**Description**	**Correction**
Midsagittal Plane (Horizontal)		
Head Rotated/Twisted/Turned	Error presents with distortion of structures right to left. Structures on one side appear narrow (labial to the focal trough) while structures on the other side appear wide (lingual to the focal tough).	Center the patient's midline so that it is straight and aligned perpendicular to the floor.
Head Tilted/Canted	Error presents similar to head rotation in terms of structure distortion. In addition, one side is higher than the other and the occlusal plane is crooked.	Center the patient's midline so that it is straight and aligned perpendicular to the floor.
Frankfort/Occlusal Plane (Vertical)		
Head/Chin Tilted Too High Up	Distorts superior structures placed lingual to the focal trough like the nasal cavities. Superimposes the hard palate over the maxillary teeth apices. Elongates the maxillary anterior teeth. Moves the condyles off the sides of the image. Occlusal plane appears flat or frowned.	Lower the patient's head/chin down until the Frankfort plane is parallel to the floor. The forehead and chin should be in the same vertical plane.
Head/Chin Tilted Too Far Down	Distorts inferior structures placed lingual to the focal trough like the chin. Superimposes the hyoid bone over the mandible. Foreshortens the anterior teeth. Moves the condyles off the top of the image. Occlusal plane appears like a grin.	Raise the patient's head/chin up until the Frankfort plane is parallel to the floor. The forehead and chin should be in the same vertical plane.
Anteroposterior Plane (Forward-Backward)		
Head Too Far Forward	Distorts the anterior teeth horizontally appearing blurred and narrowed (labial to focal trough). Superimposition of the spine onto each side of the image.	Ensure patient's teeth bite end-to-end in bite block groove. Move AP posterior to center structures in the focal trough and align with landmark.
Head Too Far Backward	Distorts the anterior teeth horizontally appearing blurred and widened (lingual to focal trough). Excessive ghosting of the rami may occur. Condyles and rami often cut off on each side of the image.	Ensure patient's teeth bite end-to-end in bite block groove. Move AP anterior to center structures in the focal trough and align with landmark.

The principal effect of positioning the patient too far back is to position structures that are normally within the focal trough, like the anterior dentition, further posteriorly and out of focus.

1. Most noticeably, severe ghosting of the ramus and mandible.
2. The anterior teeth are widened on both arches and out of focus.
3. Blurring of the turbinates (nasal conchae) across the sinus.
4. Widening of the entire image, cutting off posterior structures.

Figure 60. Head Projected.

Figure 61. Head Straightened.

Tissue Projection Errors

The second category of technical errors in panoramic radiography are tissue projection errors or those due to tissue superimposition. There are two errors possible:

Hard Tissue Projection Errors

1. **Spine** – The first hard tissue error can occur when the patient assumes the "head extended" position. One of the final instructions to patients before panoramic exposure is that they should move their feet slightly forward into the machine – a sort of "panoramic shuffle." This has the effect of straightening the cervical spine of the patient. If the patient is not instructed to do this, they will often assume a head projected position. This is because of the natural tendency of patient's is to put their head forward into the panoramic head holding apparatus rather than physically moving their head and their body. The positioning effect of this is that the spine assumes a more oblique position with respect to the x-ray beam and attenuates (absorbs) more x-rays.

   The most obvious anatomic feature of head projection is the superimposition of the spine on the ramus of the mandible and the production of a more ghost images. The most characteristic ghost image is of the spine, and it appears as a central midline radiopacity that broadens inferiorly. In addition, because of poor contrast, the dentition may be difficult to visualize because of this superimposed ghost image radiopacity.

2. **Patient Movement** – The second hard tissue error can occur when the patient moves during an exposure. Because the panoramic exposure is of the order of between 16 to 20 seconds, the possibility exists that a patient may move during the exposure. Prevention of this error can be aided by continuing to inform the patient, throughout the exposure, of the progress of the unit around their head while instructing the patient to remain still. Movement produces characteristic anatomic effects by stretching or breaking the image in the zone of movement. This may lead to the appearance of a "false" fracture. Appreciation of this artifact is important in the assessment of patients reporting with maxillofacial injury.[21] Additional presentations may result from double imaging or loss of segments. Another characteristic effect is the appearance of a dent in the lower border of the mandible.

   The effect of patient movement on the dentition can be subtle – and contribute to what could be called "motion microdontia."

Soft Tissue Projection Errors

1. **Tongue Drop** – The second tissue projection error can result from soft tissue artifacts associated with either the tongue not being placed on the palate during the exposure, or the lips not being closed. These errors occur when the patient is not instructed to place their tongue on the roof of their mouth during the entire exposure and to keep their lips together. The principal effect of this is

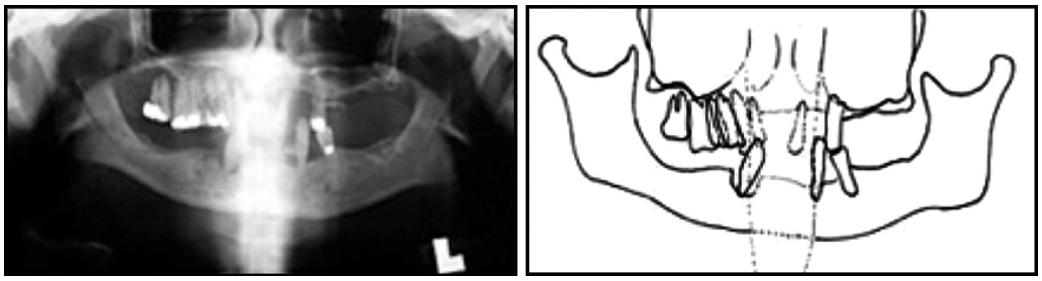


Figure 62. Panoramic radiograph (schematic on right) showing the effect of the spine on the anterior of the image with slumping of the patient.

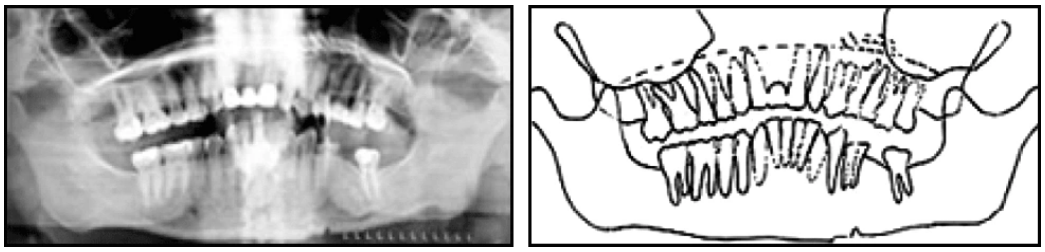


Figure 63. Panoramic radiograph (schematic on right) showing the effect patient movement on the image. Note the discontinuity of the left lower border of the mandible and distortion of dentition and palate immediately superiorly.

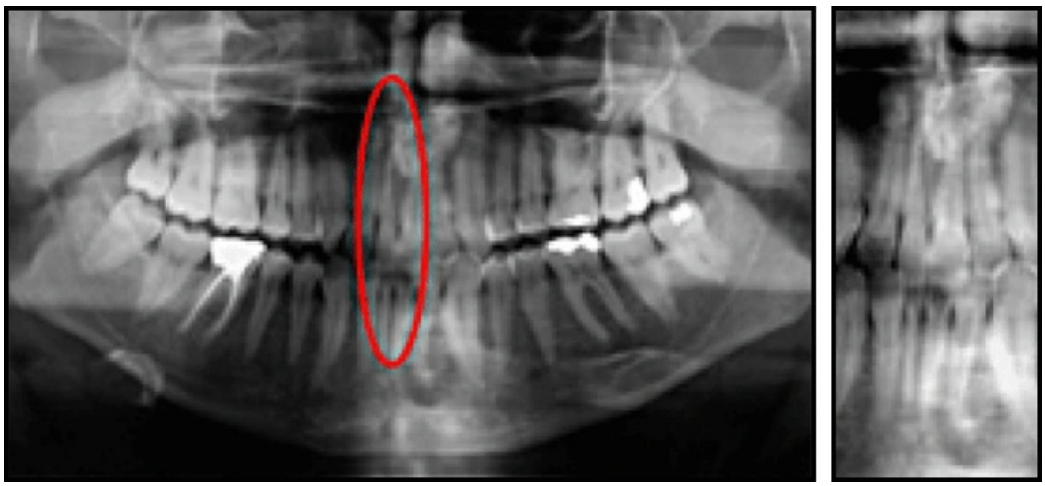


Figure 64. In this image (cropped and zoomed on right) notice that in the midline anterior region, tooth # 8 in the maxilla is extremely narrow and suggests that the patient may have a central incisor that is a microdont. On further examination it can be see that tooth # 26 in the mandibular arc, directly below # 8 is also a microdont. Further clues to this appearance being due to a motion artifact are revealed by comparing the anatomy above and below the teeth with the opposite side. This is especially apparent in the relative width of the ala or soft tissue shadow of the nose.

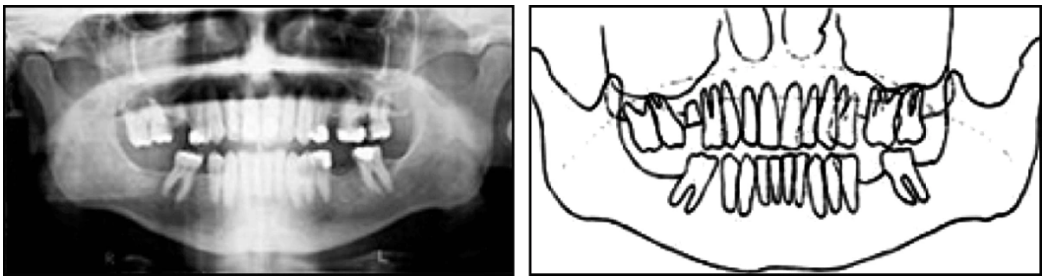


Figure 65. Panoramic radiograph (schematic on right) showing the effect of not placing the tongue on the roof of the mouth on the image.

to produce areas of relative radiolucency associated with the oro and naso pharyngeal airspaces, which can obscure visualization. This occurs because panoramic x-ray beam exposure is designed to be sufficient to transmit through both the hard and soft tissues of the maxillofacial region.

This is particularly evident with underexposed radiographs where the features of the maxilla in particular are obscured by the radiolucency created by the incorrect position of the tongue and radiopacity of the palatal hard and soft tissue.

Prevention of this error can be aided by continuing to instruct the patient, throughout the entire exposure, to keep their tongue on the roof of their mouth. Failure to place the tongue on the roof of the palate throughout the exposure does not produce any anatomic effects but does have some consequences to the visibility of the dentition.

While failure to position the tongue on the roof of the mouth is perhaps one of the most common technique errors, it is rarely the cause for a re-take. However, the effect can be accentuated in two situations when the patient is edentulous and when the patient is positioned too far forward. Failure to place the tongue on the roof of the mouth may also create apparent "apical pathology."

2. **Lips not closed** – The second soft tissue error results from the lips not being closed throughout the exposure. While there are no anatomic effects of this error, it can also contribute to "burnt out" of the crowns of the anterior teeth or be responsible for increased radiolucency over the maxillary anterior region that could be interpreted as apparent anterior bone loss.

Shoulder–Receptor/X-ray Head Interference Errors

The third category of technical errors in panoramic radiography involves shoulder and receptor contact due to short neck and/or thick shoulder anatomy and lack of clearance between the shoulder and the receptor and/or x-ray head. Contact may result in stoppage or improper machine rotation, patient movement, image artifacts or partial image production.

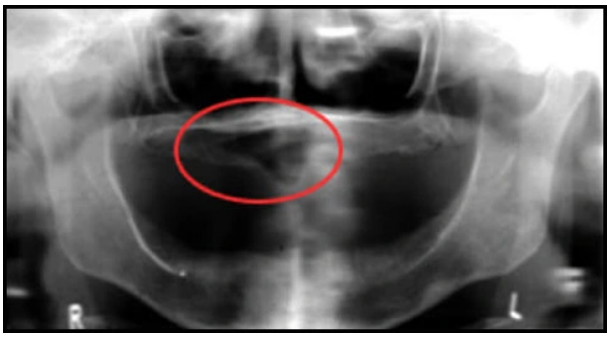


Figure 66. This image demonstrates the effect that a relaxation in tongue position during panoramic exposure can produce. Notice that in the maxillary midline there appears to be a radiolucent, cyst-like radiolucency that has expanded inferiorly below the alveolar bone. Closer examination reveals that the uppermost part of this lesion is shaped in a gradual curve – this curve represents the top of the palate and is the tell tail sign that this "lesion" has been created because the patient's tongue dropped during the exposure.

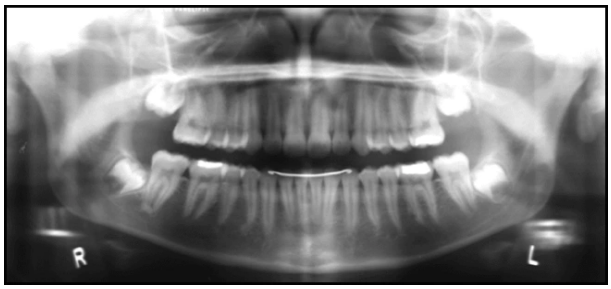


Figure 67. Panoramic radiograph demonstrating the effect that occurs when the lips are not closed during exposure resulting in an area of increased radiodensity in anterior crown regions.

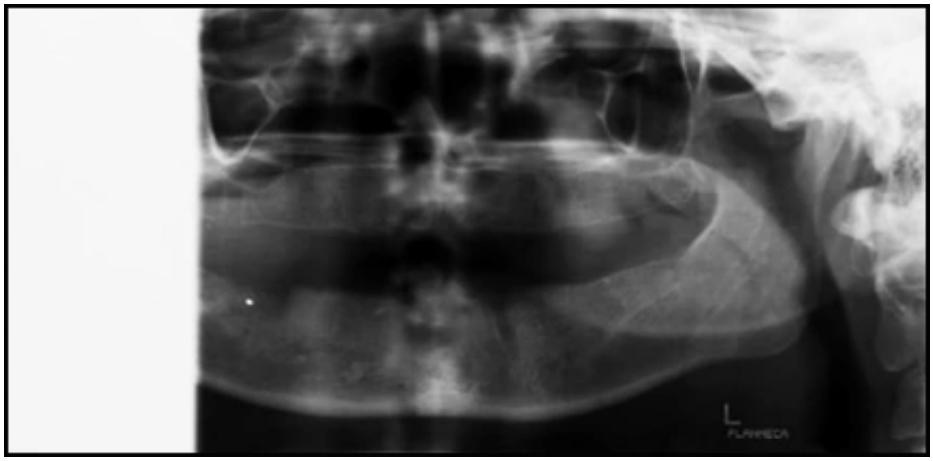


Figure 68. Shoulder contact on the patient's right caused the machine to stop resulting in an incomplete or partial image.

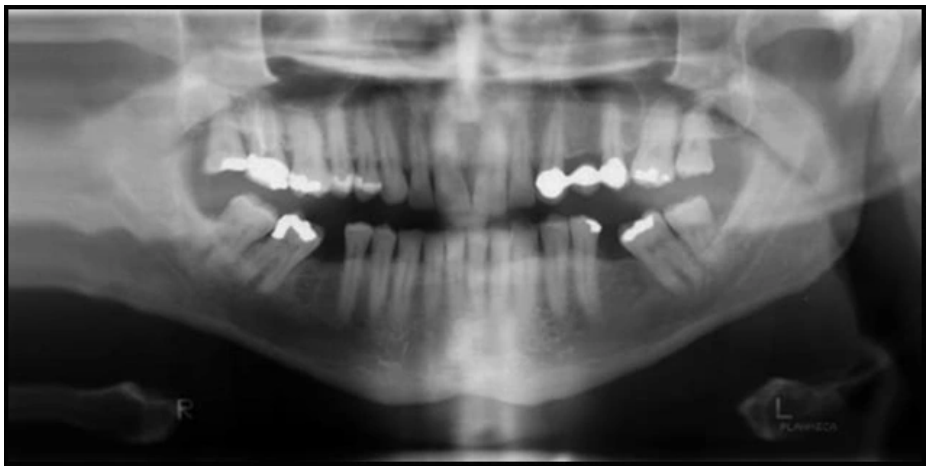


Figure 69. Shoulder contact on the patient's right side caused the patient to move in response.

Conclusion

In summary, errors in panoramic imaging can be attributed to a variety of factors but most commonly technical errors. Technical errors involve considerations of machine preparation, patient preparation and patient positioning.

Patient positioning errors can result from incorrect horizontal, vertical, or anteroposterior positioning errors, hard or soft tissue projection errors or shoulder-receptor/x-ray head interference errors.

When prescribed according to selection criteria, panoramic images provide important additional diagnostic information. While the basic underlying principles of radiography apply to panoramic and intraoral imaging, significant differences exist between the two modalities. Recognition of these differences can assist the clinician in consistently producing images of diagnostic quality. Panoramic imaging is a complex process requiring machine and patient preparation prior to patient positioning and subsequent exposure. Each panoramic image should be assessed according to specific criteria to ensure quality results are achieved. The clinician must recognize the common presentations of errors and know how to correct them to maintain quality and reduce patient re-exposure due to retakes.

Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: *www.dentalcare.com/en-us/ce-courses/ce589/test*

1. Which is considered an indication for panoramic radiographic imaging?

A. Evaluation of the mixed dentition
B. Diagnosis of interproximal carious lesions
C. Determination of furcation involvement
D. Screening for occult jaw pathology

2. Which is an accurate description of panoramic x-ray machines?

A. X-ray source rotates in front of the patient's face during exposure.
B. Operator can adjust the kVp and mA but not the exposure time.
C. Aperture of the x-ray beam source is circular in shape.
D. Image receptor is aligned at a +10º angulation.

3. Which clinical scenarios would produce radiopaque artifacts on the resultant panoramic image?

A. Head and neck jewelry not removed prior to exposure.
B. Patient's lips not completely closed around the bitepiece.
C. Patient's tongue was not placed flat against the hard palate.
D. X-ray head or receptor contact with the shoulder during exposure.

4. Which statement is descriptive of proper panoramic imaging technique?

A. Object-to-receptor distance is reduced compared to intraoral imaging.
B. Oral prostheses should remain in the mouth during patient exposure.
C. Patient should bite in normal occlusion on the panoramic bite block.
D. Thyroid collar cannot used because it will block the x-ray beam path.

5. Which phrase is an accurate description of the focal trough?

A. Configured to represent all jaw shapes, sizes, and thicknesses.
B. Image layer of structures in focus on the resultant radiograph.
C. Located between the patient's dentition and the x-ray source.
D. Wide in the anterior region and narrow in the posterior region.

6. Each feature is demonstrative of panoramic imaging technique EXCEPT one. Which is the exception?

A. The clinician aligns the patient's head according to specific anatomical planes.
B. The side closest to the image receptor is recorded in focus on the panoramic.
C. The x-ray beam rotates behind the patient's head while the receptor rotates in front.
D. The x-ray beam travels in a labial to lingual direction just like in intraoral imaging.

7. Which criterion is associated with a diagnostic panoramic radiographic image?

A. Asymmetrical display of the anatomic structures right to left.
B. Clear visualization of the proximal contacts of the teeth.
C. Occlusal plane demonstrates a slight smile configuration.
D. Spinal column, hyoid and condyles are fully displayed.

8. When determining optimal panoramic image density, what is the best region to examine to assess adequate density?

A. Dentinoenamel junction on molars.
B. Mandibular parasymphyseal area.
C. Maxillary sinus cavity anatomy.
D. Gonial angle of the mandible.

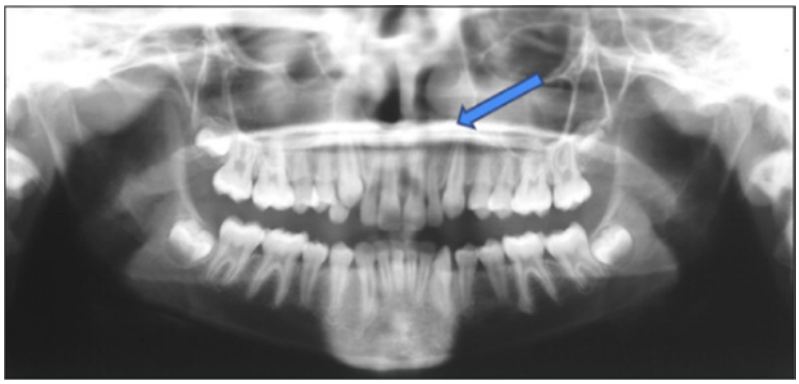
9. Which of the following problems would produce a high-density panoramic image?

A. Kilovoltage control set too low for the patient.
B. Operator let go of the exposure switch too early.
C. Use of child exposure factors for an adult patient.
D. Overestimation of patient size, stature, bone density.

10. What anatomic structure is identified by the arrow on this panoramic image?

A. Hyoid bone
B. Styloid process
C. External oblique ridge
D. Mandibular canal space

11. What is the anatomic structure identified by the arrow on this panoramic image?



A. Hard palate
B. Nasal septum
C. Maxillary sinus
D. Zygomatic arch

12. Several visual features of the dentition can be used to assess whether the teeth are positioned correctly within the focal trough. Which selection is a visual assessment feature?

A. Anterior teeth in focus with pulp canal clearly seen.
B. A grin or pronounced upward curve of teeth.
C. Tooth size discrepancy on left or right side.
D. Anterior teeth shape narrows in width.

13. Which phrase is consistent with the appearance of panoramic ghost images?

A. Recorded on the same side as the original object.
B. Magnified and unsharp in their presentation.
C. Location is lower than the original object.
D. Mirror image of the original object.

14. Which error would produce a wedge-shaped radiopaque artifact near the midline on a panoramic image?

A. The patient did not place his/her tongue against the hard palate.
B. The lead apron was placed too high up on the back of the patient's neck.
C. The operator let go of the exposure switch momentarily during the procedure.
D. The patient's spinal column was slumped and obscured the image of the midline.

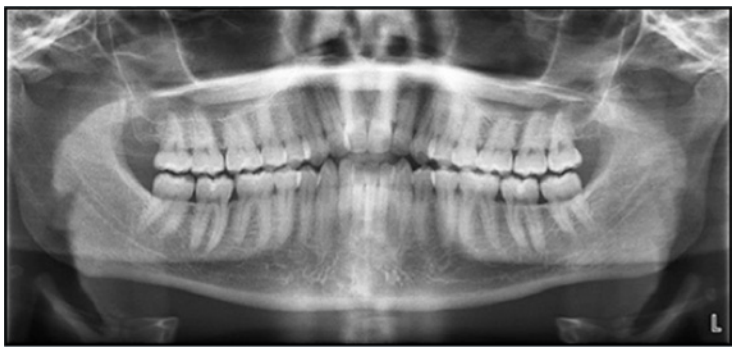
15. What type of image distortion is characteristic of midsagittal head plane errors?

A. The occlusal plane forms a frown configuration.
B. A triangular radiopacity is superimposed over the midline.
C. The lower teeth are foreshortened and blurred in appearance.
D. Structures are narrow on one side and wide on the other side.

16. What type of error is produced when the head is tilted to one side?

A. The maxillary and mandibular anterior teeth are blurred and widened.
B. The occlusal plane and the lower border of the mandible are canted.
C. Excessive ghosting of the cervical spine and the rami occurs.
D. The maxillary anterior teeth are blurred and elongated.

17.Examine this panoramic image carefully. What correction does the clinician need to make to improve the diagnostic quality of the image?



A. Realign the dental midline.
B. Straighten the patient's cervical spine position.
C. Lower the vertical placement of the patient's head.
D. Instruct the patient to bite end-to-end in the bite block groove.

18. What type of distortion will occur if the patient's head is positioned too high up?

A. The hard palate superimposes over maxillary teeth apices.
B. The occlusal plane will display a grin-like configuration.
C. The posterior teeth will appear narrowed and blurred.
D. The hyoid bone will superimpose over the mandible.

19. When the patient's head is positioned too far down, which manifestations will the clinician observe on the panoramic image?

A. One side of the arches will appear stretched while the other side will be scrunched.
B. The maxillary and mandibular anterior teeth will appear blurred and widened.
C. The occlusal plane will display a big grin or jack-o-lantern configuration.
D. A U-shaped radiopacity appears adjacent to the patient's midline.

20. If the patient's head is positioned too far back, what type of distortion will be evident on the panoramic image?

A. The cervical spine will superimpose over the ramus on both sides of the image.
B. The maxillary and mandibular anterior teeth will be blurred and widened.
C. The condyles will be pushed off the top of the image bilaterally.
D. The hyoid bone will be superimposed over the mandible.

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