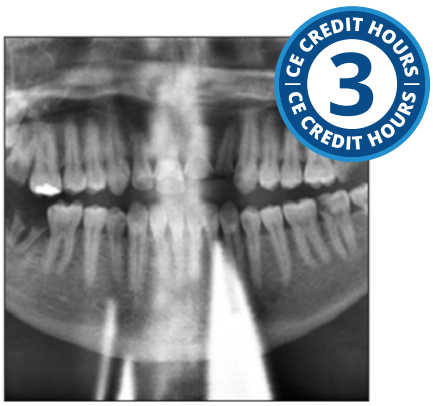
Practical Panoramic Imaging



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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

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 radiographic image will be presented.

Course Contents

Overview

Panoramic radiographic imaging technique, error recognition, and error correction are the primary topics covered in this course. The optimal production of a panoramic image will be discussed including a step-by-step technique for acquiring a diagnostic image. Interpretation of the basic anatomic structures found on a panoramic image will be presented along with 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 technical problems. This course is provided to enhance the participant's understanding of common errors and their correction with the goals to improve image quality, reduce retakes, and decrease unnecessary ionizing radiation exposure to the patient.

Syllabus: Dental Radiology

The information in this 12-module syllabus is intended (1) to meet elements of initial educational/training requirements for Dental Students, Dental Hygiene Students, and Dental Assistant Students related to dental radiography; (2) to provide a framework for an in-service training program in oral healthcare settings to meet annual educational/training requirements as mandated by federal, state, local and professional organizations; and (3) to serve as a resource for oral healthcare personnel wishing to review evidence-based information on specific topics related to dental radiography. A PDF is available for each module that may serve as a convenient resource.
Dental Radiology Syllabus

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, patient instructions, 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 the ability to recognize and correct common errors via a self-assessment exercise.

Introduction

Panoramic radiographic imaging provides the dental practitioner with an easily obtained curved-plane image of the dental arches and their supporting structures.[1] Widely used in dentistry, panoramic imaging serves as an important diagnostic technical tool for oral disease diagnoses.[2] This tomographic imaging modality is technique-sensitive and requires accurate patient positioning to obtain diagnostic results and avoid patient re-exposure. Prior to performing any radiographic imaging procedure, it is prudent for the dentist to ensure that the benefits of the examination will outweigh the risks associated with the ionizing radiation exposure.[3,4] This task is best accomplished through the application of evidenced-based radiographic selection criteria.[3,4]

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.[4] Recently a comprehensive review of dental radiation safety research, regulatory standards, and guidance from national and international agencies was completed to update several aspects of the 2012 document.[3] The resultant publication of this review provides evidenced-based recommendations to assist practitioners to develop and enact safety practices that will not only optimize diagnostic image value but also minimize radiation risks to patients and personnel.[3] Relevant updated evidenced-based recommendations will be discussed in the foregoing content.

Selection criteria guidelines indicate that the use of panoramic examinations in combination with posterior bitewings is an option for imaging new patients in the child (transitional dentition), adolescent, and adult categories.[4] 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.[4] The resultant diagnostic information should help the dentist determine the type of imaging needed, if any, and its frequency. Dentists should prescribe radiographic images only when they expect that the additional diagnostic information will have an impact on patient care.[4] 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.[4,5]

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.[6,7] 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

Table 1. Selection Criteria Guidelines.[4]

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.

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.[6,7]

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.[8] This study reaffirmed that there was no net diagnostic benefit to the patient with the use of panoramic radiographic images as a routine screening tool.[8]

In addition, Benn and Vig published a study in 2021 which estimated US dental practice radiographic-associated cancer cases.[9] 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 (CBCT) 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.[9]

Therefore, it is not only judicious but also necessary for the dentist to follow selection criteria guidelines so that the determined survey, whether intraoral, panoramic or a combination thereof, or CBCT, is appropriate for the patient and will produce a high yield result while simultaneously minimizing radiation exposure.[3] The recent comprehensive review reiterated the importance of selection criteria and appropriate imaging practices to reduce radiation exposure to patients as well as adherence to all relevant regulatory requirements.[3]

Comparisons to Intraoral Radiography

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

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-ray 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 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. (Figure 1)

- **Milliamperage (mA) Control** - The mA 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 noticeably alter image density*.
- **Kilovoltage (kVp) Control** – The kVp 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 or darkness. *A 5% difference is required to visibly alter image density.*
- **Time Control** – The timer 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.5,10 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. (Figure 2) In comparison, panoramic x-ray units have a narrow vertical slit aperture. (Figure 3) 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 vertical angle (approximately -10°) and rotates behind the patient's head during the exposure cycle. (Figure 3)

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

Digital 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 film-based panoramic radiography but the receptor, processing, display, storage, and transmission capabilities differ. [5,11] Both types of digital image receptors will produce diagnostic results when properly utilized and maintained.

Figure 2. Intraoral X-ray Unit.
Source: 2002 Heliodent DS, Sirona

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. (Figure 4) The patient is aligned in the same head positions as required in film-based panoramic x-ray machines.(Figure 5) The computer processes the image as it is acquired. Then, the image is displayed on the computer monitor in real time.(Figure 6) The image is archived in the patient database and electronic patient record. The acquired images can be viewed in diverse ways through the application of software enhancement tools.

Figure 3. Digital Panoramic X-ray Unit.
Source: 2009 Proline Panoramic XC, Planmeca

Direct Digital Panoramic Imaging

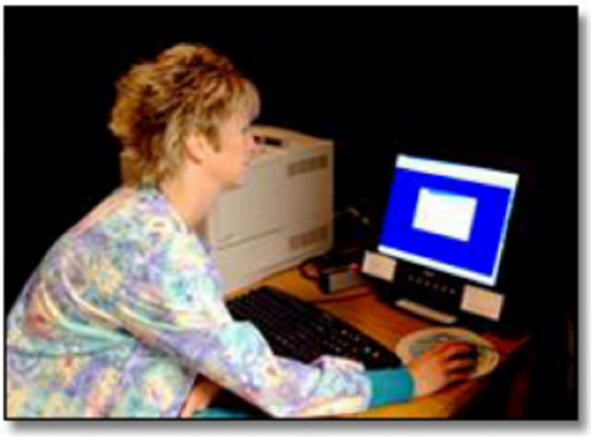


Figure 4.

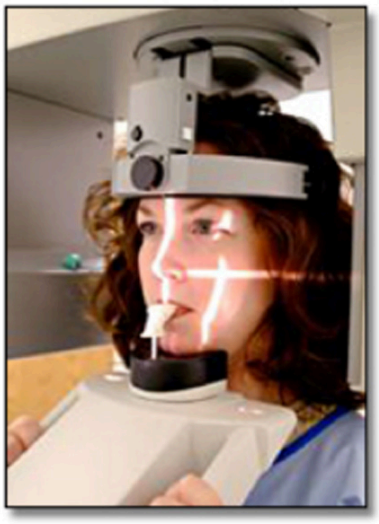


Figure 5.

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.[7] 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.[7,8] 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 time-saving, electronic 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.

Figure 6.

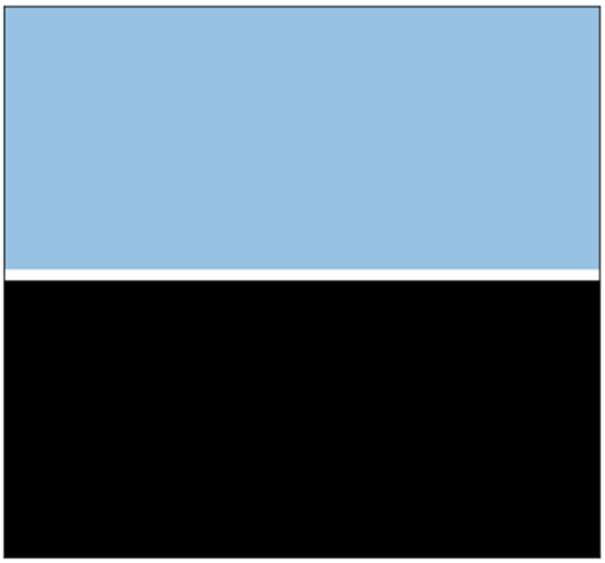


Figure 7. Photostimulable Phosphor Plate.
Emulsion or exposure side – Blue
Non-exposure side - Black

Image quality, regardless of receptor type, remains operator-dependent. The technical requirements of proper patient preparation, positioning, and exposure selection are essential to produce optimal results and to avoid retakes.

Quality Assurance and Quality Control
Quality assurance (QA) in dental and maxillofacial radiography requires that specific steps are taken to provide diagnostic images while minimizing patient radiation exposure.[1,3] This is accomplished through compliance with manufacturer and regulatory measures regarding device usage.[1,3] Quality Control (QC), an integral part of QA, concentrates on testing and measurement of radiographic devices, image receptors, and other technical components of the imaging chain.[3,13] The purpose of QC is to ensure that the entire imaging system maintains a consistent level of acceptable performance according to national standards and guidance.[1,3,14,15]

To ensure consistent high-quality panoramic images, a quality assurance program should be in place and conducted by qualified personnel. NCRP Report 177 advises that the QA/QC program be established in consultation with a qualified expert to include procedures for documentation of QC measures, designation of qualified personnel responsible for each activity, monitoring of results, and mechanisms to enact corrective actions to remedy identified issues or substandard performance.[1] It is recommended that a retake log be maintained to help monitor the number of retakes and the causal errors. Identification of recurring errors indicates a need for continuing education and in-service staff training to eliminate repeated errors and unnecessary patient re-exposure.

Specifically x-ray machines should be inspected periodically for output, kilovoltage calibration, half value layer, timer accuracy, milliamperage reproducibility, and collimation as required by state law. Regular testing, planned monitoring, and scheduled maintenance of x-ray equipment, digital image receptors, scanning and display equipment are all important aspects of a comprehensive QA/QC program.[1] In addition, machine operators must be qualified and credentialed according to state regulations.

Intraoral Patient Preparation

Regardless of receptor type used for panoramic image capture, the patient must be prepared properly prior to the procedure. The first step is to explain the general aspects of the imaging procedure to the patient. The clinician will need to reinforce and coach the patient during the imaging process. 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. The clinician should take care to safely store these items and return them to the patient when the process is complete.

Figure 8A and 8B. Removal of metallic head and neck objects.

Radiation Safety

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 not be alarmed by the mechanical function of the panoramic machine. These instructions are important to prevent movement or head positioning errors that could result in a retake and additional patient radiation exposure.

The use of patient shielding during panoramic imaging procedures has been controversial for many years. Current evidence-based findings indicate that abdominal and thyroid shielding for diagnostic intraoral, panoramic, cephalometric, and CBCT imaging are no longer necessary.[3,16] Their use should be discontinued as a routine practice and as needed, federal, state, and local regulations and guidance requiring routine use of such shielding should be revised to reflect evidence-based recommendations.[3] As seen in Figure 9, use of these shields can produce radiopaque artifacts by blocking the primary x-ray beam, obscuring anatomical structures, causing retakes, and increasing the radiation dose to the patient.[3,16] In addition, abdominal and thyroid shields do not protect the patient against internal radiation scatter.[16]

Dose Comparisons

The radiation doses associated with radiographic imaging examinations in dental practice are typically low-dose intraoral and panoramic procedures.[3] 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-image bitewing survey using PSP receptors and rectangular collimation is equivalent to approximately a half day of background radiation.[5,17] By comparison, a CCD panoramic survey is equivalent to approximately one to three day(s) of background radiation depending on the machine and background radiation standards.[5,18] The guiding principle is adherence to selection criteria and ensuring that any necessary radiographic examination is obtained at a dose level that is as low as reasonably achievable (ALARA).[19]

Figure 9. Panoramic Image with Midline Radiopaque Lead Apron Artifacts.

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. (Figure 10) Many machines display a vertical alignment light or mirror to adjust the midsagittal plane to ensure that the right and left sides of the dental arches will be equally imaged and 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. (Figure 11) The tragal-canthus plane (tab in ear to outer corner of the eye), and the ala-tragus plane (corner of nose to tab in the ear) 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 when viewing the patient's head in profile.

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. (Figure 12) 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.

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.

Figure 10. Midsagittal Plane.

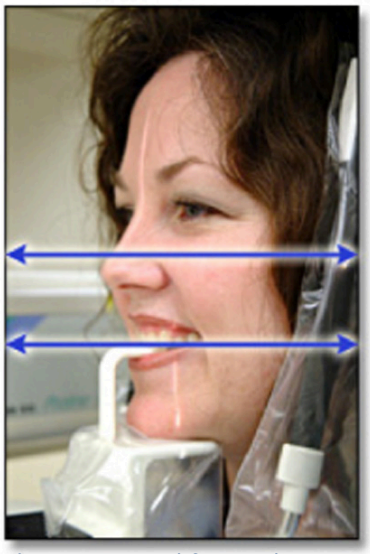


Figure 11. Frankfort and Occlusal Plane.

Figure 12. Anteroposterior Plane.

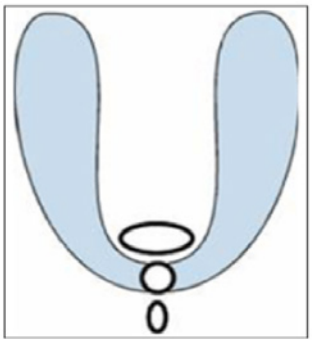


Figure 13A. Resultant curved image layer that corresponds to arch shape.

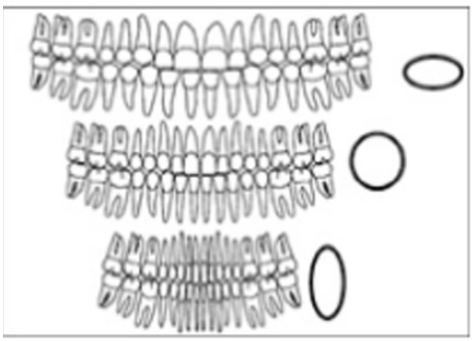


Figure 13B. Mispositioning relative to the focal trough alters structures most significantly in width.

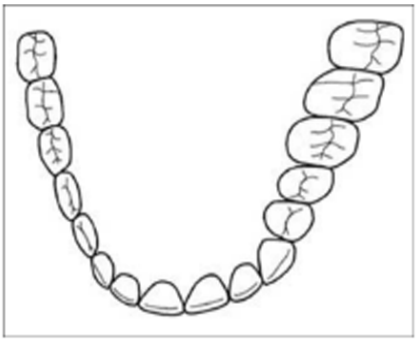


Figure 13C. Horizontal malpositioning results in one side appearing narrow and the other wider.

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 13A-C).

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

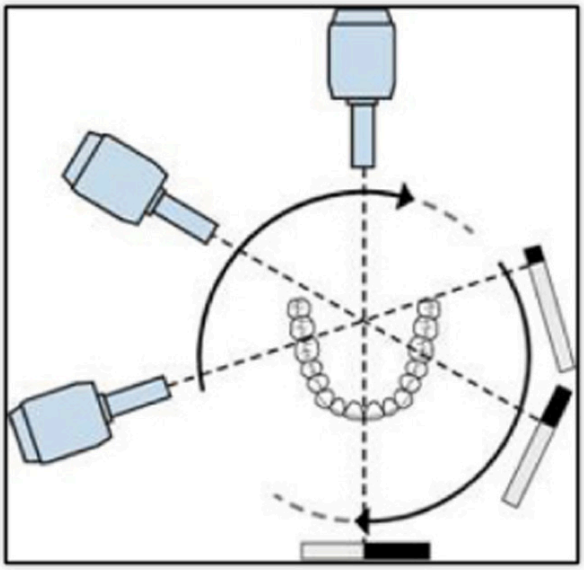


Figure 14. Schematic diagram of simple panoramic motion incorporating slit beam radiography and linked motion of x-ray tubehead and receptor.

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 15A and 15B. Digital Panoramic Unit Control Panels. Source: 2009 Proline Panoramic XC, Panmeca.

Number 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.

Figure 16. C-arm Assembly
Source: 2009 Proline Panoramic XC, Panmeca.

- *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.

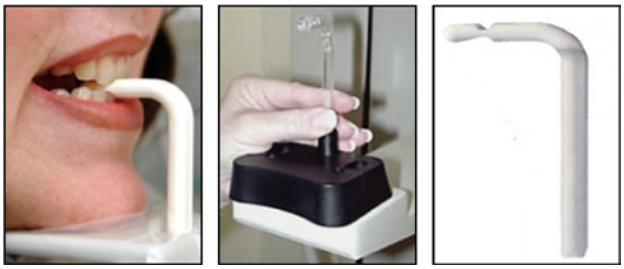


Figure 17 A-C. Patient Positioning Devices.

Steps in Taking a Panoramic Image

Procedural Steps

Table 2. Steps in Panoramic Imaging Procedure.

Unit Preparation
- Ensure machine is on and ready for patient imaging.
- Use standard infection control procedures to prepare the unit.[5,20]
- Place clean barriers over components that will contact the patient.
- Insert sterile panoramic bite block.
- Create patient file to acquire the image.
- Set the exposure factors based on patient size and stature.

Patient Preparation
- Explain the procedure to the patient prior to 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.
- 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 while keeping the spine erect.
- 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 the 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 swallow and 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 the 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 the hand grips until they step back and are stable.
- Check the image for diagnostic quality before saving. Retake only if necessary.
- Return oral prostheses and head/neck metallic objects to the patient.
- Guide patient back to the operatory.
- Return to unit and complete follow-up infection control procedures.5,20

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 ensures 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 features 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.

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, preferably the latter.

Position machine slightly higher than patient's chin. Prior to machine entry, the approximate height of the patient should be determined, and the chin rest adjusted to a level slightly higher than the patient's chin. When the patient attempts to bite in the grooves of the bite block, they must 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.

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

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 metal 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" projections 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 regarding for the need to remove these items prior to exposure.

Patient Positioning and Instructions

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 preferably to keep the shoulders down. 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 or duck 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.

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 in the bite block coincide with the middle plane of the anterior portion of the focal trough which is the mechanism by which the anteroposterior position of the head is is established. 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 can detect 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, ask the patient to align their head by looking at their reflection in the mirror and adjusting the position of their head so that the line equally divides their face right to left.

Adjust head vertically. 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. (Figure 18) 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 18 and 19)

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 or centered over the maxillary 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 press the 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, swallow, and press their entire tongue against the roof of their mouth and keep it there throughout the exposure.

Figure 18. Panoramic unit (OP100, Instrumentarium Imaging) with light beam reference guides projected onto the patient's face to help the clinician align the head.

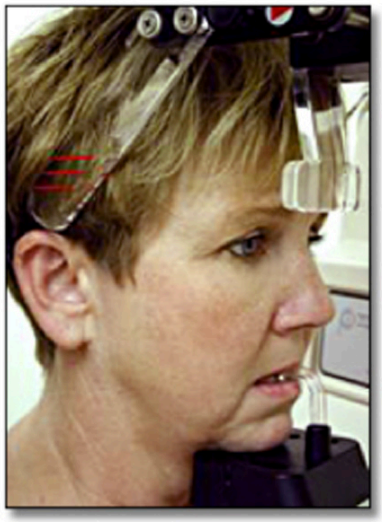


Figure 19. Panoramic unit (PC1000, Panoramic Corp.) with external reference guides on lateral head holders to align the vertical head plane.

Figure 20. Final Head Position

According to Rushton et al., 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%).[21] 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.[22-24]

Alternate Pre-exposure Instructions. Alternate pre-exposure instructions can be employed to help reduce the tongue placement error. This method developed by Scott and Reed is based on the simple breathing technique (SBT) which utilizes the known position of the tongue during respiration.[25] The SBT avoids any mention of the tongue which often is confusing to patients.[25] Prior to entering the machine, the clinician can demonstrate the technique and invite the patient to join them in practice. The steps include: 1) breathe-in through the nose, 2) breathe-out through the mouth, 3) swallow with your lips closed and 4) hold still.[25] Once the patient is positioned in the machine and the head is properly aligned, the patient is reminded to repeat the steps when they hear the clinician give the instructions.[25] The authors suggest that the final instructions be given slowly five second after the exposure switch is engaged.[25] The exact timing may require adjustment depending on the specific panoramic machine used.[25] The SBT has proven to be effective in airspace error reduction, particularly in children and special care patients.[25]

Exposure & 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 and,

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 hold still 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 due either to the spontaneous patient movement (e.g. cough, sneeze) or 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

Diagnostic Criteria

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

Table 4. Panoramic Diagnostic Criteria.

- Entire maxilla, mandible, 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 premolars, 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.

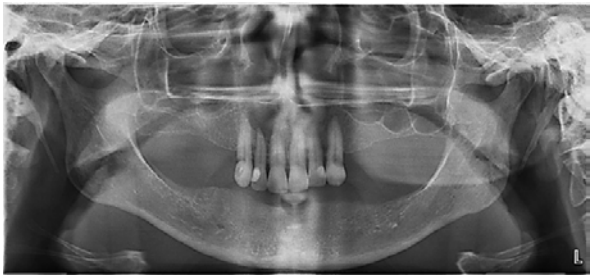


Figure 21. Optimal Panoramic Radiograph.

In reality, most panoramic images are not optimal nor ideal but rather present with minor yet acceptable error(s) that do not interfere with diagnosis and treatment planning. In such instances, a retake is not justified.

Figure 22. Panoramic Image with Minor Errors. This panoramic image demonstrates a slight downward tilt of the patient's head evidenced by a minor grin of the occlusal plane, slight foreshortening of the mandibular incisor teeth. In addition, the tongue was not placed against the palate. However, these minor errors do not interfere with the overall diagnostic acceptability of the image.

Figure 23. Panoramic Image with Minor Errors. This panoramic image demonstrates a slight upward tilt of the patient's head evidenced by a flat occlusal plane, slight elongation of the maxillary incisor teeth, and minor superimposition of the hard palate over some of the maxillary teeth apices. However, these minor errors do not interfere with the overall diagnostic acceptability of the image.

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 capture all the structures of the maxillofacial region. If any of the structures are not present, either because they are not covered or obscured, then a retake is indicated. 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 24 demonstrates three of the most common reasons for retakes; neither 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.

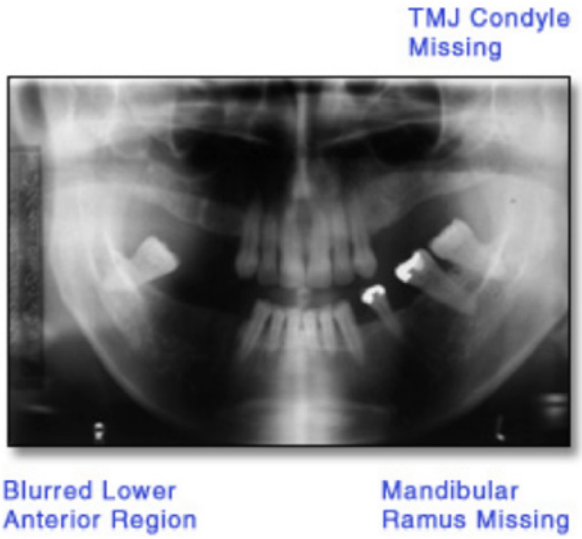


Figure 24. Unacceptable Panoramic Image

Figure 25 demonstrates three further reasons for retakes: poor visualization of the maxillary anterior region, inadequate 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.

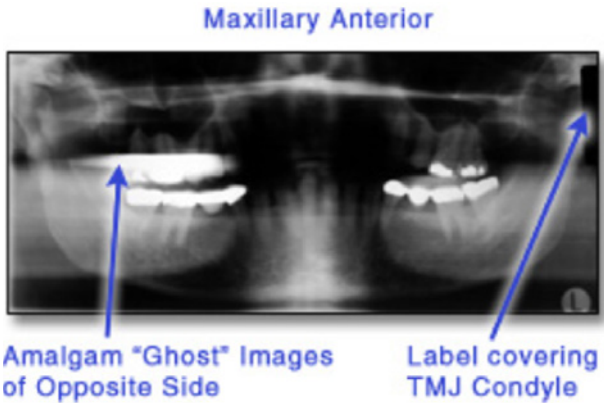


Figure 25. Unacceptable Panoramic Image

Features of an Optimal Panoramic Image

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

Figure 26. Optimal Panoramic Image.

Example of an excellent edentulous panoramic radiographic image with 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.

- **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 proper 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.

- **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 dentin can be seen, usually in the molar region. The dentinoenamel junction (DEJ) should be apparent.

Anatomical Structures

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.

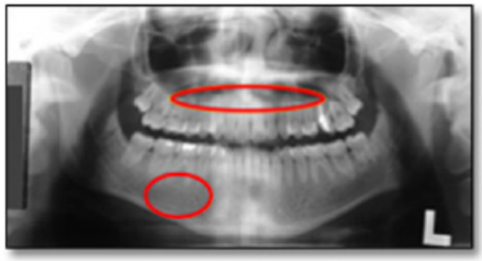


Figure 27. Density Assessment.
Regions on a panoramic radiograph to look at to determine adequate density.

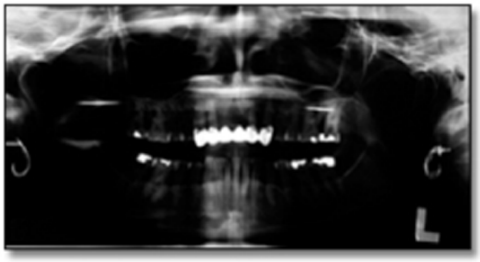


Figure 28. Overexposure.
Example of an overtly dark, overexposed panoramic image.

Excessive Exposure Examples:

Figure 29A. Original Panoramic Image. **Figure 29B.** Enhanced Panoramic Image
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.

Underexposure Examples:

Figure 30A. Original Panoramic Image. **Figure 30B.** Enhanced Panoramic Image.
Images demonstrating how inadequate exposure can lead to failure to detect pathologic features. The 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 mandibular third molar.

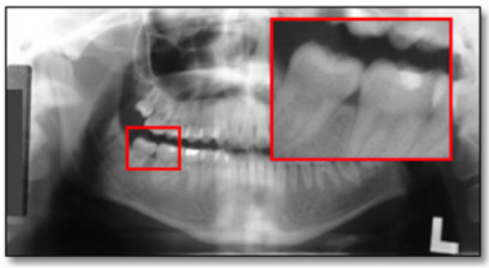


Figure 31. Contrast Assessment. DEJ evaluation for panoramic image contrast.

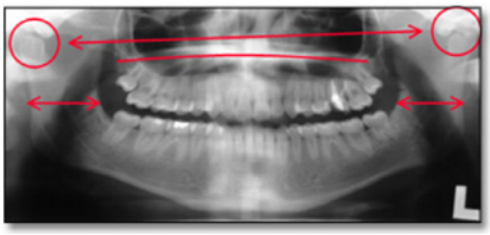


Figure 32. Anatomic Assessment Features. Compare specific structures to assess panoramic anatomic accuracy.

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.

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.

Identifying Panoramic Errors

Panoramic radiographic imaging is technique dependent. The clinician must address all aspects of machine and patient preparation, positioning, instruction, and exposure to produce a quality result. A number of authors indicate that the quality of panoramic radiographic images taken either in an institutional setting,[22-24,27-29] in general dental practice, or submitted to third party insurance providers[21,26] is low. In most instances, a small percentage of panoramic images were found to be error free and many panoramic images demonstrated multiple errors.[21,23,24,26-30]

In 2014, Rondon et al., conducted a review of the literature to determine the most common types of patient positioning errors.[27] The most

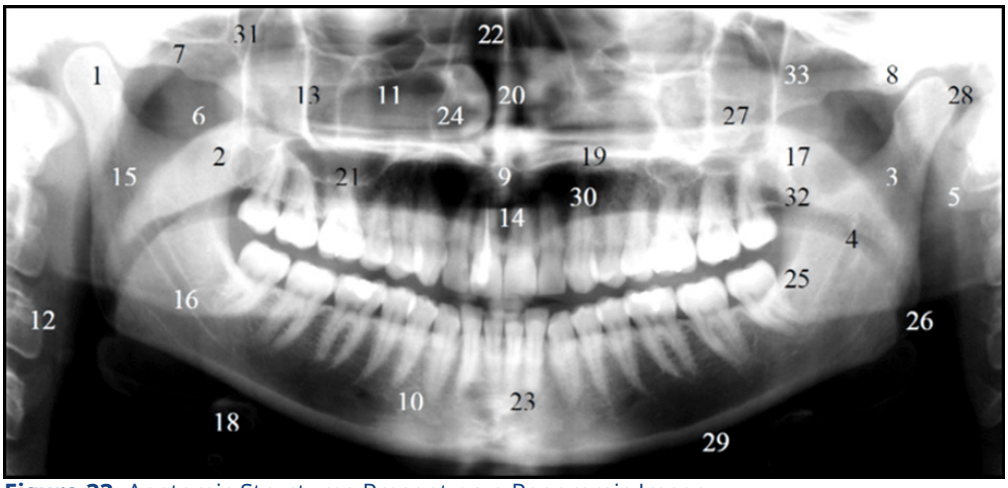


Figure 33. Anatomic Structures Present on a Panoramic Image.

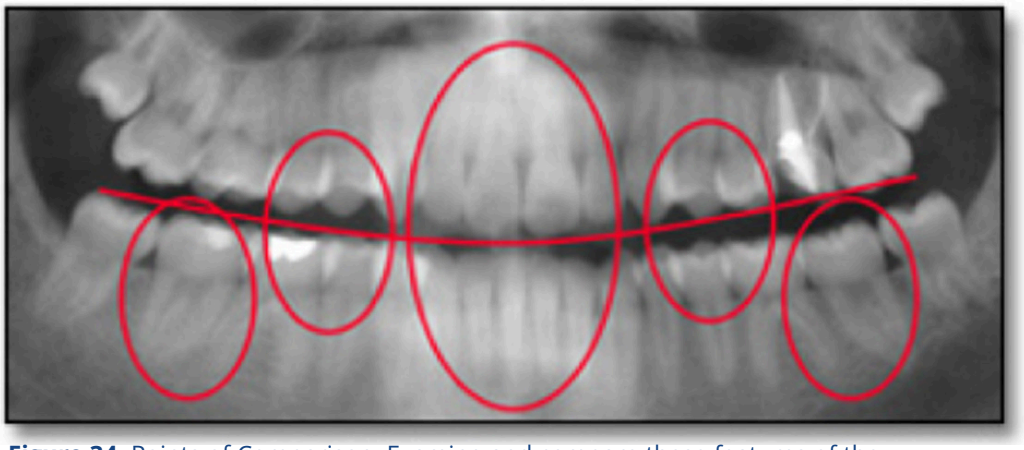


Figure 34. Points of Comparison. Examine and compare these features of the dentition to assess panoramic anatomic accuracy.

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

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.[27]

Asha et al. conducted a review of 560 digital panoramic radiographs in 2018.[29] 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. Slumped spine, and
7. Head too far forward.[29]

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 from the patient's head and neck. This causes two problems:
  1. First, they produce a radiopaque outline of themselves, usually providing a telltale indication of the error.
  2. Second, they may produce "ghost images." Ghost imaging is a normal component of 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.

Normal anatomic structures can also produce ghost images. Figure 36 demonstrates ghost images of the angle of the mandible which are projected to the other side and identified by the arrows.

Machine Preparation Errors

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

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 35. Panoramic Earring Ghost Images. This image illustrates the telltale signs of leaving several metallic objects on the patient, specifically earrings, glasses, and a neck chain. Note the ghost images produced by the earrings and their characteristic presentation.

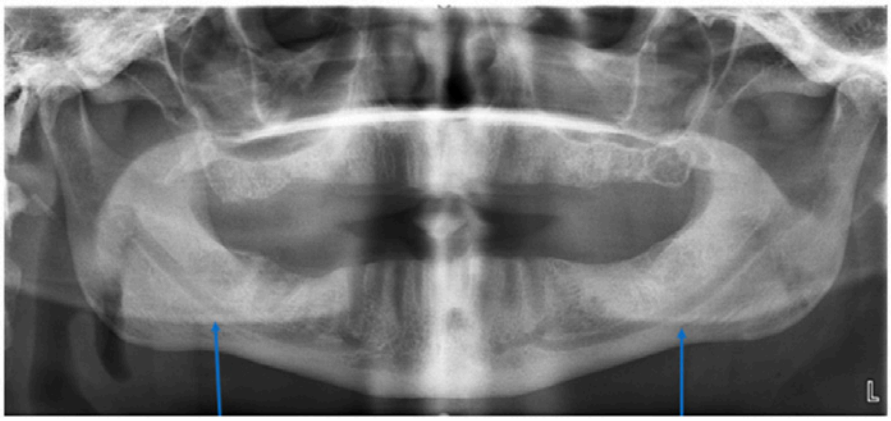


Figure 36. Ghost of the Angle of the Mandible.

the 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 setting 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 37) and underexposure (Figure 38) 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 can occur on panoramic units with variable program options is forgetting to reset the program selection after the patient is dismissed. This results in exposure of the next patient using the wrong program rather than the standard one.

Figure 37. High Density Image: Overexposure.

Figure 38. Low Density Image: Underexposure.

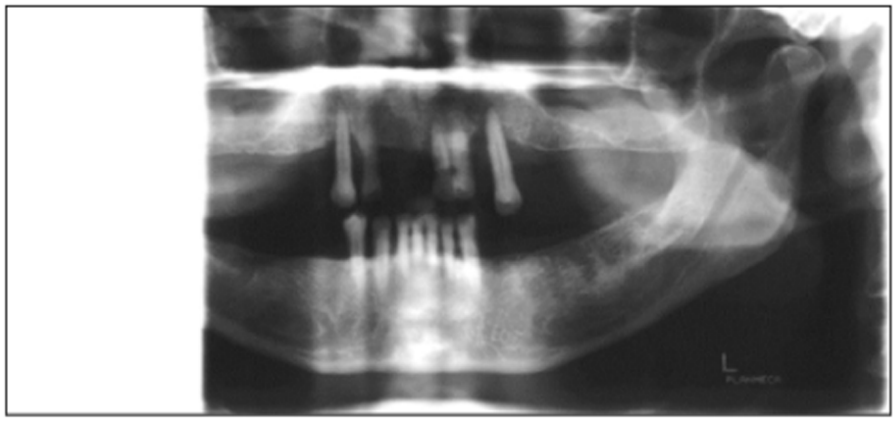


Figure 39. Incomplete Exposure.

Figure 40A. Incorrect Program Selection.

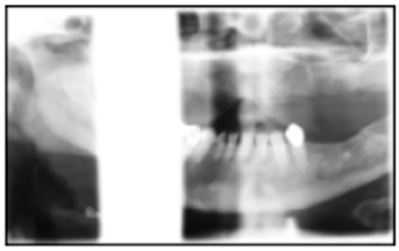


Figure 40B. Incorrect Program Selection

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 third 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 easily be recognized by careful analysis of the position, relationship of structures, unsharpness and distortion in a panoramic image. The visual effects of incorrect patient positioning 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

Sub-category 1: 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 which will produce multiple and sometimes compounding effects and, thus, are referred to as "compound" errors. The analysis of positioning errors involves stepwise recognition of the radiographic features associated with each planar discrepancy.

Horizontal plane discrepancies – These errors 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, 1) twisted (rotated) with respect to the machine (Figure 41), or 2) that their head is tilted (Figure 42). Both occur because the midsagittal plane of the patient's head is not correctly aligned at the time of exposure. This can happen if the patient "follows" the receptor during exposure and moves off-center.

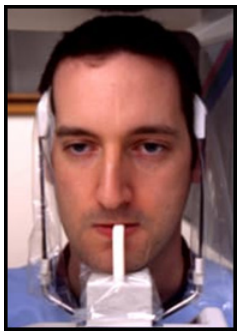


Figure 41.
Rotated/Twisted/Turned.

Figure 42.
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 mispositioning 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 "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's head 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. These errors 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

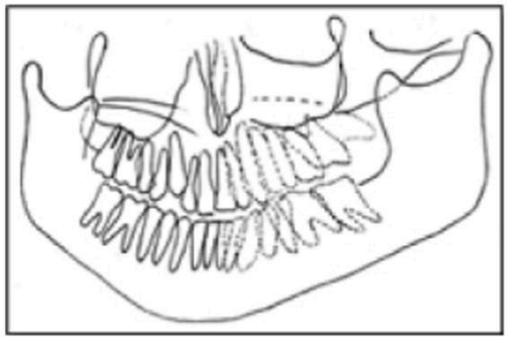


Figure 43A. Panoramic image
Figure 43B. Panoramic Schematic
These figures demonstrate the effects of twisting. Elongation of left mandible, reduction in size of teeth on the opposite side, occlusal plane canting and pronounced tooth overlap on the same side.

Figure 44A. Panoramic image

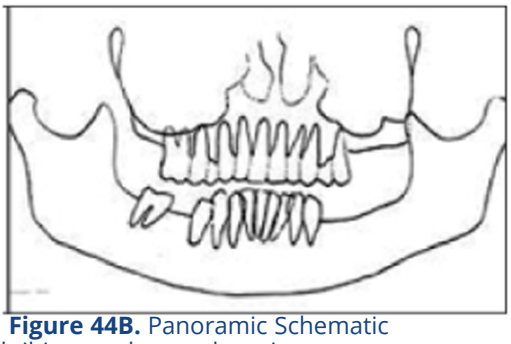


Figure 44B. Panoramic Schematic

These figures demonstrate the effects of head tilting on the resultant image.

is positioned too far up, too far down, or 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 or inferiorly in the machine. The instructions in the manufacturer's manual may vary in the plane that 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.
  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 tilted too far down. The principal effect of tilting the chin down is to position more of the maxilla into the focal trough, align the maxillary teeth, and to bring less of the mandibular anterior area into the focal trough. The anatomic effects of positioning the head too far down can be severe and may necessitate retaking the image.
  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.

Figure 45. Head/Chin Up.

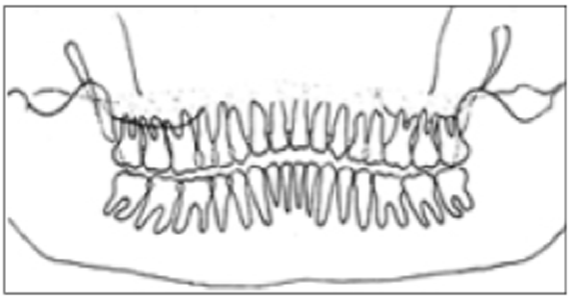


Figure 46A. Panoramic Image. **46B.** Panoramic Schematic
These figures demonstrate the effects of positioning the head too far up.

- **Chin not on chin rest**. The third possibility is that the patient's chin is lifted from the chin rest. This usually happens 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, they will straighten themselves up.

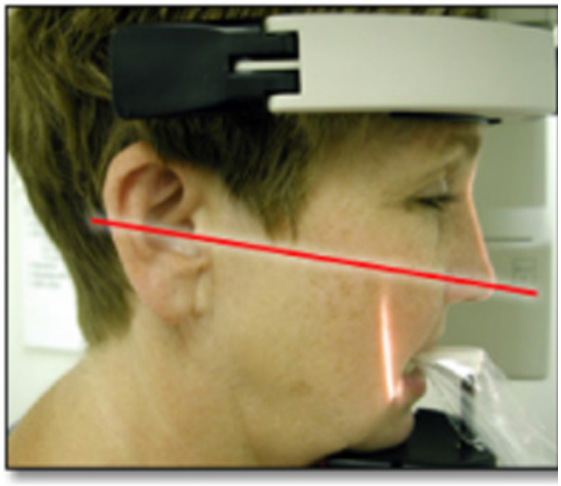


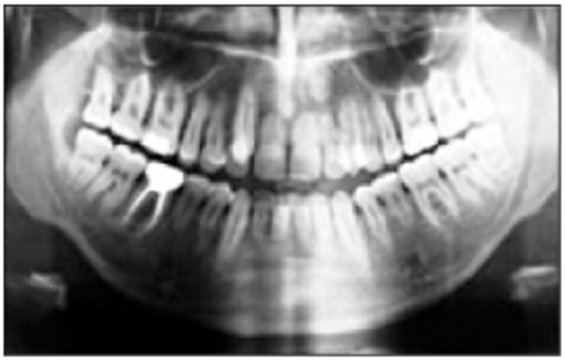
Figure 47. Head/Chin Down

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. These errors alter the position of the teeth, especially the anterior teeth in the focal trough. The two likely options are that the patient is positioned too far forward or too far backward.

Too far forward. Anterior positioning of the patient too far forward occurs due to patient slipping forward beyond the bite piece groove, 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 groove. Prevention of subsequent patient movement can be aided by adjustment of the forehead support, when available, to prevent the patient from sliding forward.



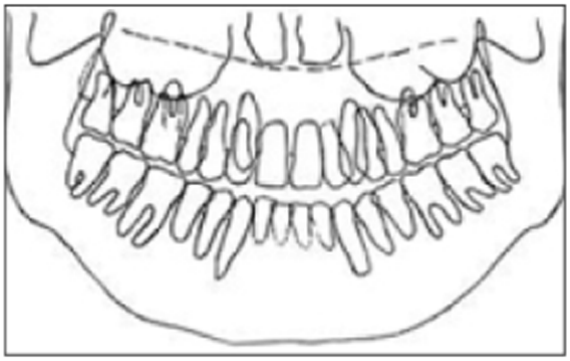


Figure 48A. Panoramic Image **Figure 48B.** Panoramic Schematic.
These figures demonstrate the effects of positioning the head too far down.

Figure 49A. Panoramic Image. **Figure 49B.** Image Cropped and Zoomed.
The original panoramic image and a cropped/zoomed version of the same image demonstrate the effects of positioning the head off the chin rest. Note that in addition to that error, the patient is positioned too far forward, and the head is tilted.

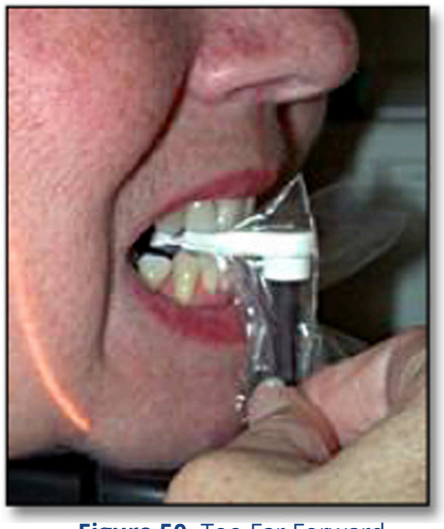


Figure 50. Too Far Forward

The effect of positioning the patient too far forward is to place 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, the 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 occurs.

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 groove. In instances when the patient has trismus or their jaws are wired together; the clinician can use the bite piece to measure the approximate distance to position the patient on the chin rest.

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

a. Most noticeably, severe ghosting of the ramus and mandible occurs.
b. The anterior teeth are widened on both arches and out of focus.
c. Blurring of the turbinates (nasal conchae) across the sinus occurs.
d. Widening of the entire image, causing cutting off of posterior structures.

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	Error distorts superior structures placed lingual to the focal trough such as the nasal cavities. Causes superimposition of the hard palate over the maxillary teeth apices. Elongates the maxillary anterior teeth. Moves the condyles off the sides of the image. Causes the occlusal plane to appear 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	Error distorts inferior structures placed lingual to the focal trough such as the chin. Causes superimposition of the hyoid bone over the mandible. Foreshortens the anterior teeth. Moves the condyles off the top of the image. Causes the occlusal plane to have a grin-like appearance.	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	Error distorts the anterior teeth horizontally, appearing blurred and narrowed (labial to focal trough). Causes 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	Error distorts the anterior teeth horizontally, appearing blurred and widened (lingual to focal trough). May cause excessive ghosting of the rami. Condyles and rami are 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.

Figure 51A. Panoramic Image.

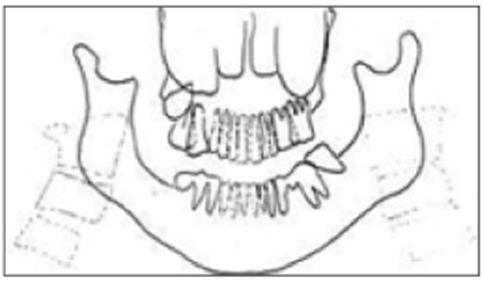


Figure 51B. Panoramic Schematic.

These figures demonstrate the visual effects on the image when the patient's head is too far forward during exposure: spine superimposes over the ramus area, nasal fossa and maxillary sinus become clearly evident, and the anterior teeth are narrowed and blurred.

Figure 52A. Panoramic Image.

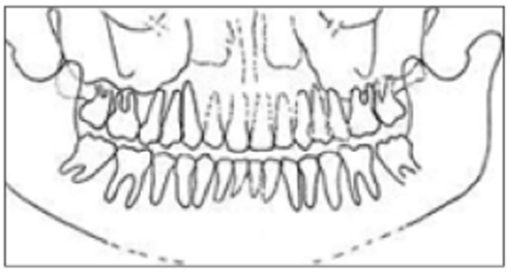


Figure 52B. Panoramic Schematic.

These figures show the 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, blurring of the turbinates across the sinus, and pronounced widening of the anterior teeth.

Sub-category 2: Tissue Projection Errors

The second category of technical errors in panoramic radiographic imaging are tissue projection errors or those due to tissue superimposition. Two errors are 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 to 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 often adopt a projected head position. This occurs because the natural tendency of patient is to put their head forward into the panoramic head holding apparatus rather than physically moving their head and their body simultaneously. The positioning effect of this action places the spine into 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 ghost image. 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 due the radiopaque superimposed ghost image.

2. **Patient Movement.** The second hard tissue error can occur when the patient moves during an exposure. Because the panoramic exposure is approximately 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 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.[29] 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 type of tissue projection error can result from soft tissue artifacts associated with either the tongue not being placed against the palate during the exposure, or the lips not being closed. These errors occur when the patient is not instructed to place their tongue against the

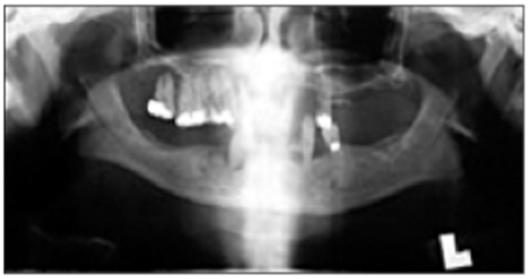


Figure 53A. Panoramic Image.

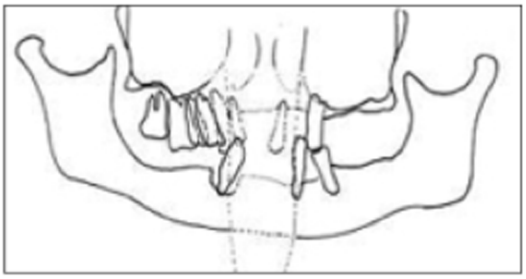


Figure 53B. Panoramic Schematic.

These figures show the blocking effect of the spine on the anterior aspect of the image when the patient is in a slumped position.

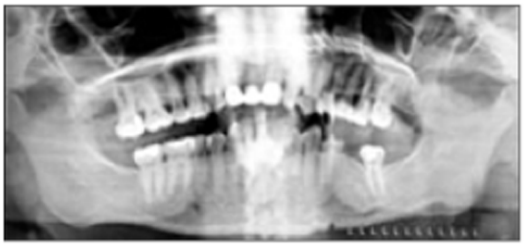


Figure 54A. Panoramic Image.

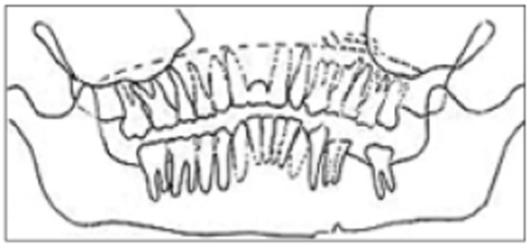


Figure 54B. Panoramic Schematic.

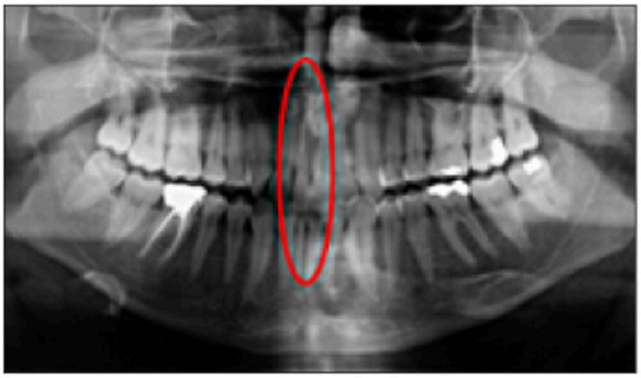


Figure 55. Panoramic Image.

Figure 56. Cropped/ Zoomed Section.

These figures depict the maxillary central incisor, tooth #8, as extremely narrow, suggesting that the patient may have a microdont central incisor. Further examination demonstrates that mandibular lateral incisor, tooth #26, directly below #8 also looks like a microdont. Additional clues that is 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.

roof of their mouth during the entire exposure and to keep their lips closed. These gaps produce areas of relative radiolucency associated with the oropharyngeal and nasopharyngeal 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. Particularly evident in underexposed panoramic images, the features of the maxilla are obscured by the radiolucency created by the incorrect position of the tongue and radiopacity of the palatal hard and the soft tissue. Prevention of this error can be aided by continuing to instruct the patient throughout the exposure, to maintain tongue contact against the roof of their mouth. Failure to do so does not produce any anatomic effects but does have some consequences with respect to the visibility of the dentition.

While failure to position the tongue properly is one of the most common technique errors, it is rarely the cause for a retake. 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 correctly 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.

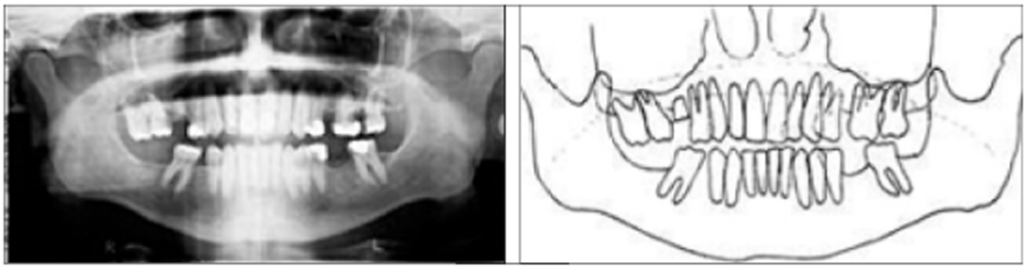


Figure 57A. Panoramic Image. **Figure 57b.** Panoramic Schematic.
These figures illustrate the effect on the image from lack of placing the tongue against the roof of the mouth.

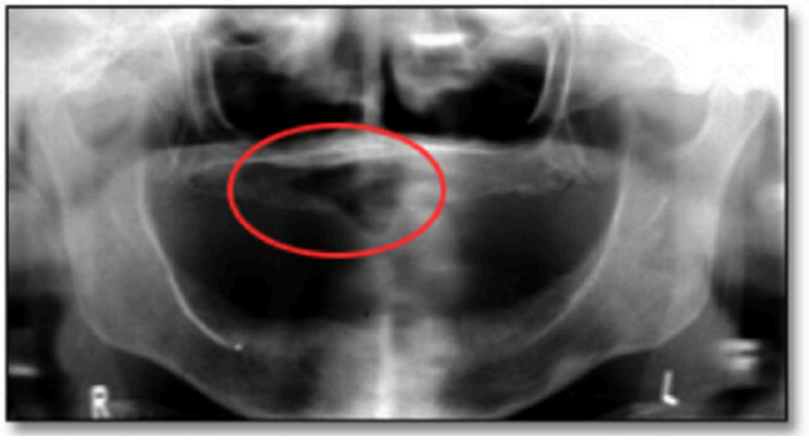


Figure 58. This image demonstrates the effect that a relaxation in tongue position during panoramic exposure can produce. Notice that in the maxillary midline there appears to be a radiolucent, cyst-like radiolucency that has expanded inferiorly below the alveolar bone. Closer examination reveals that 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.

Sub-category 3: Shoulder–Receptor/X-ray Head Interference Errors

The third category of technical errors in panoramic radiography involves shoulder and receptor contact due to patient 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.

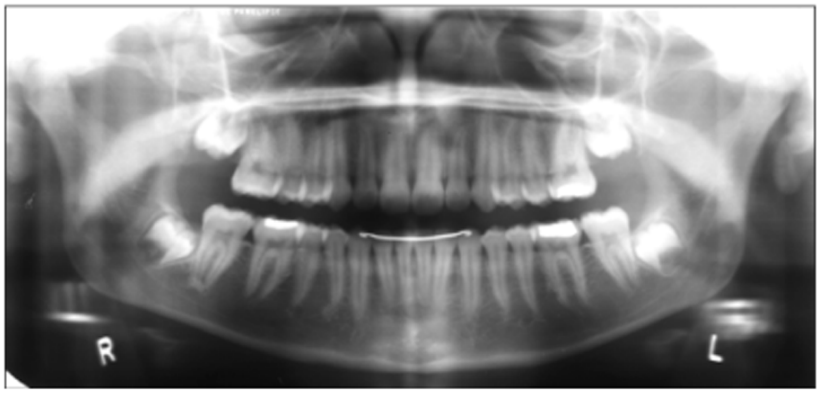


Figure 59. Panoramic Image with Open Lips. This image demonstrates the effect of open lips during exposure producing an area of increased radiodensity of the anterior teeth crowns.

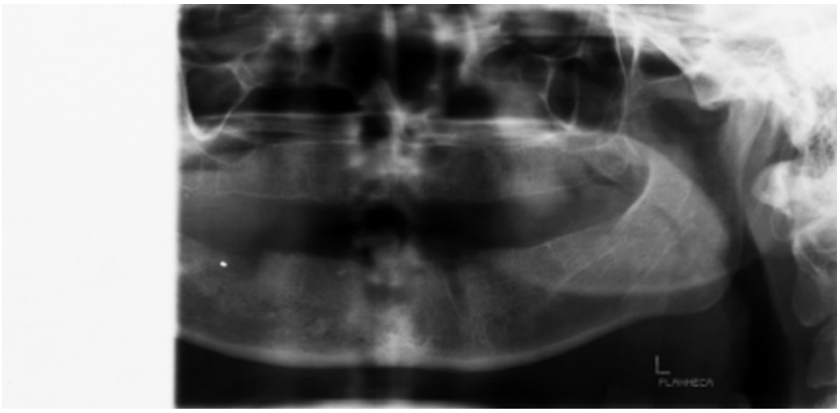


Figure 60. Incomplete Panoramic Image. Shoulder contact on the patient's right side caused the machine to stop resulting in a partial image.

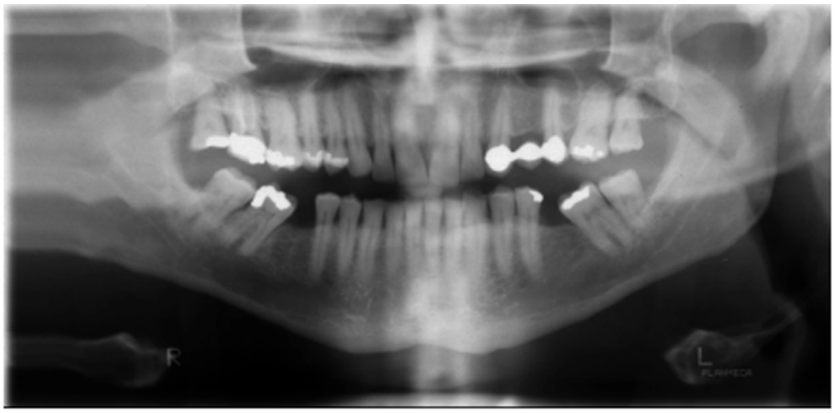


Figure 61. Distorted Panoramic Image. Shoulder contact on the patient's right side caused the patient to move in response producing wave-like distortion and cut-off the right ramus.

Conclusion

In summary, errors in panoramic imaging can be attributed to a variety of errors 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, important 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. According to selection criteria guidelines, panoramic radiographic imaging is appropriate for which diagnostic task?

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

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

A. Aperture of the x-ray beam source is circular in shape.
B. Exposure time is fixed but the kVp and mA are variable.
C. Receptor rotates behind the head while x-ray head moves in front.
D. X-ray beam travels through patient structures labial to lingual.

3. What is the primary focus of quality control within the dental office quality assurance program?

A. Establishment of a panoramic retake log.
B. Operator training and credential certification
C. Scheduled equipment repair and maintenance.
D. Testing and measurement of imaging chain.

4. Which patient preparation error would result in the production of radiopaque artifacts on a panoramic image?

A. Hearing aids not removed prior to x-ray exposure.
B. Lips not completely closed around the bite piece.
C. Tongue was not in place against the hard palate.
D. Receptor contacts the shoulder during exposure.

5. Which step has been eliminated as part of the panoramic imaging procedure?

A. Adjustment of the program mode on the panoramic machine control panel.
B. Instruction of the patient to bite end-to-end on the panoramic bite block.
C. Placement of abdominal or thyroid shields prior to patient x-ray exposure.
D. Removal of oral prostheses from the mouth prior to patient positioning.

6. In panoramic imaging, the focal trough is

A. configured to represent all jaw shapes, sizes, and thicknesses.
B. defined as the layer of structures in focus on the recorded image.
C. located between the patient's dentition and the source of x-rays.
D. shaped wider in the anterior region compared to the posterior.

7. What is the correct panoramic alignment for vertical placement of the patient's head?

A. Ala of the nose
B. Frankfort plane
C. Maxillary lateral contact
D. Midsagittal plane

8. Which criterion is consistent with a diagnostic panoramic radiographic image?

A. Clear visualization of the proximal contacts of the dentition.
B. Hyoid bone, spinal column, and condyles are fully displayed.
C. Occlusal plane demonstrates a flat or frowned configuration.
D. Symmetrical display of the anatomic structures right to left.

9. When determining optimal panoramic image density, which region is best for the assessment of adequate density?

A. Dentinoenamel junctions
B. Mandibular parasymphyseal
C. Maxillary sinus cavity
D. Pterygomaxillary fissure

10. Which situation would result in a high-density panoramic image?

A. Holding down the exposure button for too long.
B. Overestimation of the patient's size and stature.
C. Selection of an inadequate milliamperage setting
D. Use of child exposure factors for an adult patient.

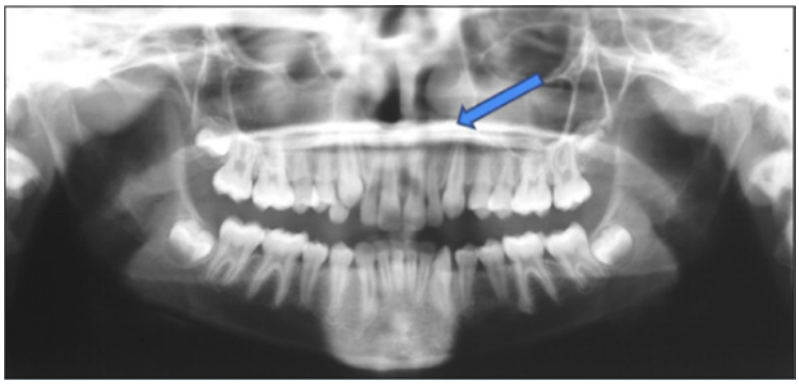
10. What anatomic structure is identified by the arrow on this panoramic image?

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

12. 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

13. Which visual assessment feature is used to determine whether or not the teeth were positioned correctly within the focal trough?

A. Anterior teeth are in focus with pulp canal clearly seen.
B. Anterior teeth shape appear narrow in width dimension.
C. Occlusal plane displays a pronounced grin or upward curve.
D. Tooth size discrepancy exists on either the left or right side.

14. Which description is consistent with the appearance of panoramic ghost images?

A. Located lower than the original object.
B. Magnified and unsharp in their presentation.
C. Presents a mirror image of the original object.
D. Recorded on the same side as the original object.

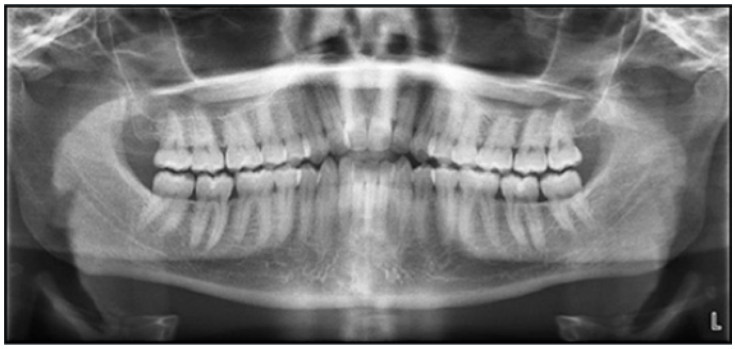
15. What type of image distortion is characteristic of midsagittal head plane errors?

A. Lower teeth are foreshortened and blurred in appearance.
B. Occlusal plane forms a downward frown configuration.
C. Structures are narrow on one side and wide on the other side.
D. Triangular radiopacity is superimposed over the midline.

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

A. Excessive ghosting of the cervical spine and the rami occurs.
B. Lower border of the mandible and occlusal plane are canted.
C. Maxillary and mandibular anterior teeth are blurred and widened.
D. Maxillary anterior teeth are both 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. Lower the vertical placement of the patient's head.
B. Instruct the patient to bite end-to-end in the bite block.
C. Realign the patient's dental midline.
D. Straighten the patient's cervical spine position.

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. Hyoid bone superimposes over the angle of the mandible.
C. Occlusal plane displays a broad grin-like configuration.
D. Posterior teeth appear both narrowed and blurred.

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

A. Maxillary and mandibular anterior teeth are blurred and widened.
B. Occlusal plane display a Halloween jack-o-lantern smile configuration.
C. One side of the arches are stretched while the other side are scrunched.
D. U-shaped radiopacity appears adjacent to the patient's dental midline.

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

A. Cervical spine is superimposed over the ramus on both sides of the image.
B. Condyles are projected off the top of the panoramic image bilaterally.
C. Hyoid bone is superimposed over the lower border of the mandible.
D. The maxillary and mandibular anterior teeth are both blurred and widened.

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Figure 60. Head Projected.

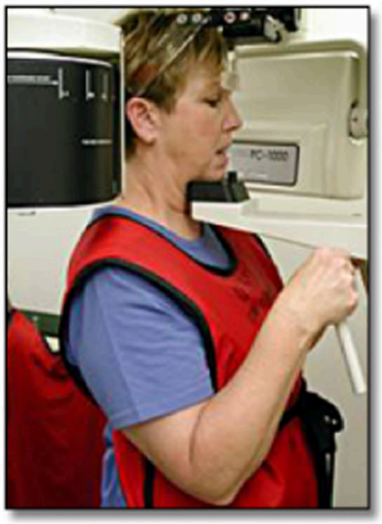

Figure 61. Head Straightened.

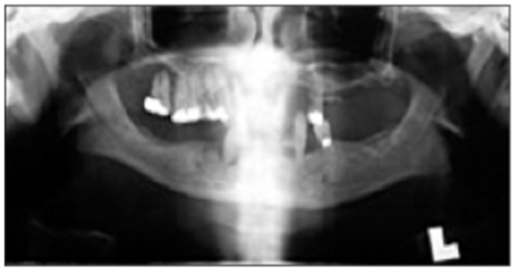

Figure 53A. Panoramic Image.

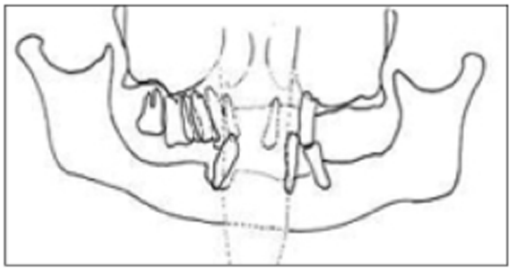

Figure 53B. Panoramic Schematic.

These figures show the blocking effect of the spine on the anterior aspect of the image when the patient is in a slumped position.

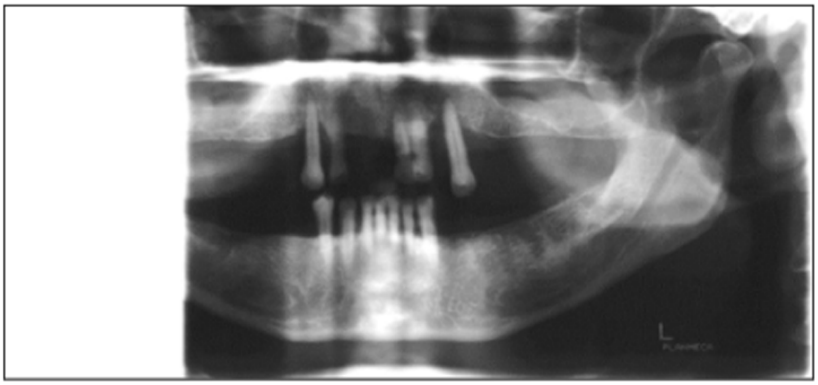

Figure 60. Incomplete Panoramic Image. Shoulder contact on the patient's right side caused the machine to stop resulting in a **partial image.**

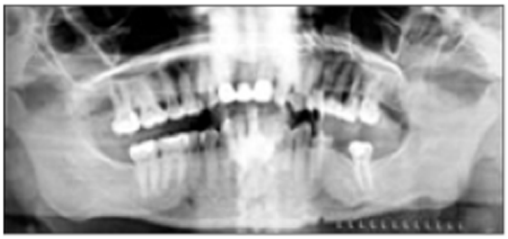

Figure 54A. Panoramic Image.

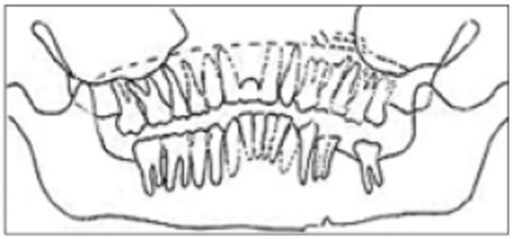

Figure 54B. Panoramic Schematic.

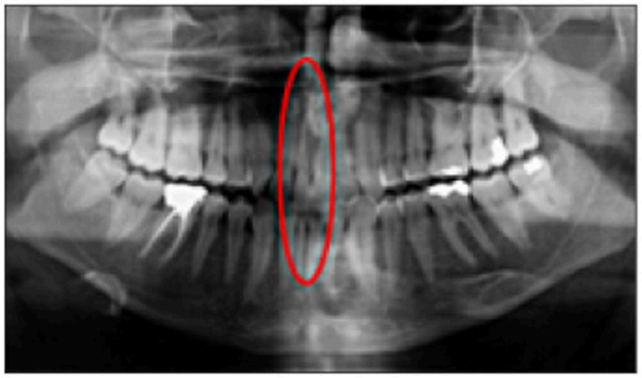

Figure 55. Panoramic Image.

Figure 56. Cropped/ Zoomed Section.

These figures depict the maxillary central incisor, tooth #8, as extremely narrow, suggesting that the patient may have a microdont central incisor. Further examination demonstrates that mandibular lateral incisor, tooth #26, directly below #8 also looks like a microdont. Additional clues that is 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 57A. Panoramic Image.

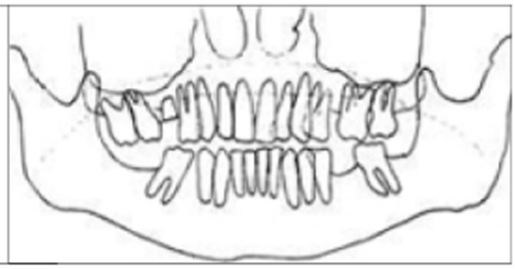

Figure 57b. Panoramic Schematic.

These figures illustrate the effect on the image from lack of placing the tongue against the roof of the mouth.

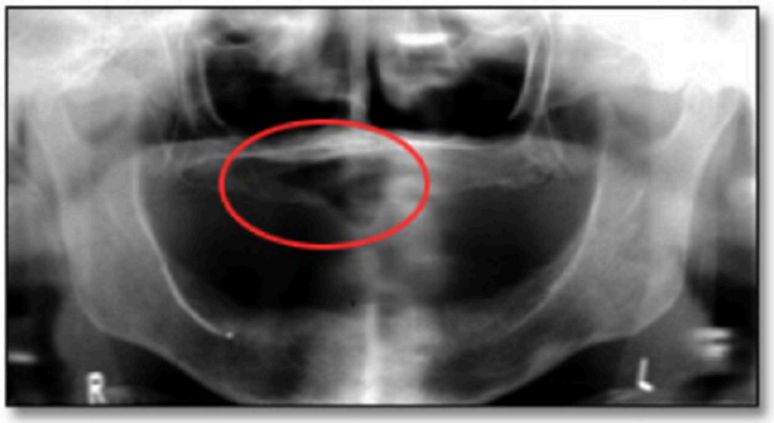

Figure 58. This image demonstrates the effect that a relaxation in tongue position during panoramic exposure can produce. Notice that in the maxillary midline there appears to be a radiolucent, cyst-like radiolucency that has expanded inferiorly below the alveolar bone. Closer examination reveals that 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.