# 4 Basic Principles of Panoramic Radiography

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## 4.1 Panoramic Radiography

The idea of showing all dental arcs on a single film was introduced by Bouchacourt in 1904. Bouchacourt considered recording the image of the arcs on a film outside the mouth, giving the X-ray source through inside the mouth. Then, in 1949, panoramic radiography technique has been developed with the efforts of Prof. Dr. Yrjo V. Paatero [1].

Panoramic radiography is a technique that enables imaging of a single tomographic image of both dental arches and adjacent anatomic structures with minimal geometric distortion and superposition ([2], s. 7). Panoramic radiography is a technique that shows all teeth and jaws, the maxillary region up to the 1/3 upper part of the eye socket, maxillary sinuses, mandible and temporomandibular joint together [1] (Fig. 4.1).

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**Fig. 4.1** Representative Panoramic Image showing the entire maxilla, mandible and dentomaxillofacial region

## 4.2 Panoramic Devices Used in Dentistry

Panoramic devices used in dentistry are divided into four basic groups as **single rotation centers (rotograph)**, **two rotation centers (panorex)**, **three rotation centers (ortopantomograph)**, and **continuous rotation centers (GE-Panel IPS)** according to the rotation center, number, and localization of the X-ray [3] (Fig. 4.2).

### 4.2.1 Single Rotation Centered (Rotograph)

In this technique, the cassette is prepared in a curved shape in accordance with the shape of the jaw. The beam source is constant and emits a very fine beam. The patient and the film rotate in front of the beam at the same speed but in the opposite


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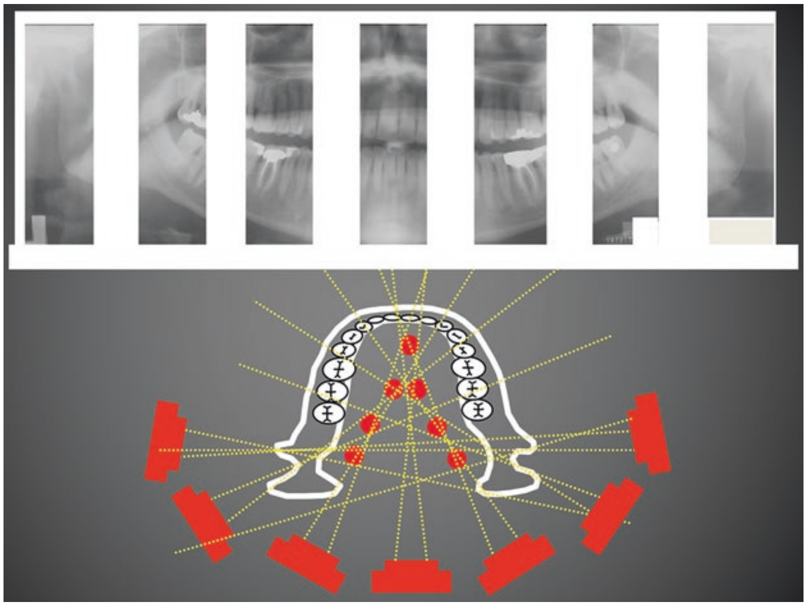

**Fig. 4.2** The development of panoramic radiography devices. (Courtesy of Prof. Dr. Dobó-Nagy Csaba)

direction. The image of the lower and upper jaws is obtained on an X-ray film that is displaced by a narrow beam [1].

In this technique, since the dental arch is accepted as a circle and a single rotation center is created and the jaws cannot be represented with such a single circle, a great amount of distortion occurs [3].

### 4.2.2 Two Rotation Centered (Panorex)

This technique is based on the tomography of curved surfaces. These are also used in flat cassettes. The head of the patient is fixed and the X-ray tube and film cassette rotate around the patient's head [1]. In this device, the right and left sides of the tooth curve are considered as separate parts of a circle and two separate rotation centers are created accordingly [3]. The first center of rotation is in the right molar area. The X-ray tube and cassette rotate around the patient's head, creating an image of the left side up to the midline on the film. In the meantime, the X-ray is automatically cut and the patient is shifted 7.5–10 cm to the right with the seat on which he sits, thus creating a second center of rotation. Meanwhile, the exit point of the central beam is shifted to the left side of the patient's spine. The tube and cassette start moving again.

The image of the right side of the chin is obtained from the back. In radiographs obtained with this technique, the image formed in the lateral parts of the dental arch is satisfactory. However, cutting the beam for a while as the tube moves behind the cervical vertebra leaves an empty space in the middle of the radiograph. These radiographs are either left as they are, or the two sides are combined with each other by cutting the empty part in the middle [1].

### 4.2.3 Three Rotation Centered (Ortopantomography)

The diameters of the jaw arcs are more in the posterior region and less in the anterior region. For this reason, there are three separate rotation centers corresponding to two posterior regions and one anterior region. A segment between the condyle and the premolar region is considered as an anterior segment, and a rotation center is available for each segment. While the jaws are examined with these three separate segments, a continuous, view is obtained from condyle to condyle [3]. There is a special cephalostat on this appliance. The head of the patient is fixed here.

The X-ray tube and the film cassette are rotated in proportion to each other around the patient's head. The cassette also revolves around itself [1].

The slit-shaped lead collimator placed on the X-ray source and the film holder allows the central beam to reach the film as a vertical beam by narrowing the X-ray beam [3]. When the X-ray machine starts up, the X-ray tube and rotation center are on the right side of the patient, and the cassette is on the left. Image recording starts from the patient's left side and continues towards the midline. When the central beam reaches the left canine, the center of rotation changes. This second center is a point in the middle of the two canines. The region between canine and canine is recorded on the film while rotating around the center. When the central beam reaches the right side canine, the center of rotation changes again. This third center of rotation is around the left third molar. The image of the part from the right canine to the upper part of the right temporomandibular joint is obtained [1].

### 4.2.4 Continuous Rotation (GE-Panel IPS)

Normally, the fact that the teeth are lined up in the jaw arches in a semielliptical manner has led to the selection of an elliptical rotation center and this system is called elipsopantomography. With this system, superpositions between neighboring teeth are tried to be minimized [3]. Today, panoramic devices with a continuous rotation center are preferred instead of multi-rotational panoramic devices. This feature optimizes the shape of the image layer and reveals the teeth and the structures that support it. The center of rotation starts from the right side of the body near the lingual surface of the mandible, continues from the back of the patient, the midline is visualized when it comes to the neck, then the arc continues in the sagittal plane and the image is complete ([4], p. 166) (Fig. 4.3).

## 4.3 Indications of Panoramic Radiographs

- For initial diagnostic purposes.
- Comprehensive evaluation of maxilla and mandible.
- Trauma.
- Wisdom teeth localizations.
- Known or suspected large lesions.
- Dental development examinations in the mixed dentition period.
- TMJ pains.
- In people who cannot tolerate intra-oral radiographs.

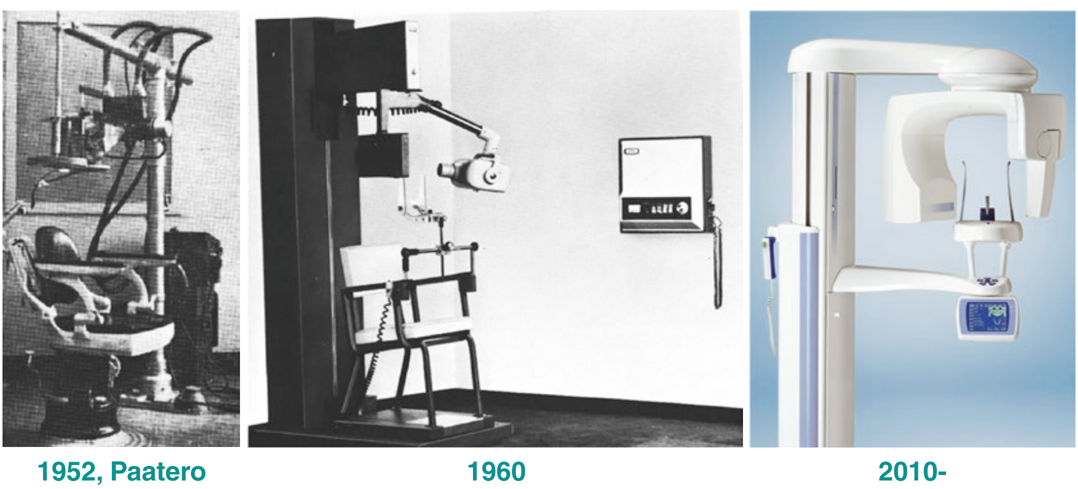


**Fig. 4.3** Image showing panoramic device with a continuous rotation center

Panoramic radiography has many advantages including short time for the procedure, greater patient acceptance and cooperation, overall coverage of the dental arches and associated structures (more anatomic structures can be viewed on a panoramic film than on a complete intra-oral radiograph series), simplicity, low patient radiation dose.

The dose to the patient is approximately ten times less than full-mouth survey using the long cone and E+ film and it is four times less than four bitewings using the long round cone and E+ film.

The panoramic radiograph is less confusing to the patient than a series of small separate intra-oral radiographs, making it easier for the dentist to explain the diagnosis and treatment plan to the patient.

The panoramic radiograph is an excellent imaging modality in patients with trismus or trauma, because such patients cannot open their mouths and this is not required to take a panoramic film. It is an excellent projection of diverse structures on a single film, which no other imaging system can achieve.

In such cases, the high resolution and detail available in intra-oral radiographs is not required. Panoramic imaging is also an imaging technique that can often be used in the initial evaluation of situations that require further projections ([5], p. 175).

Although panoramic radiography is a curvilinear variant of conventional tomography, it works on the principle that there is also an image receiver with a reciprocal moving X-ray source located around a central point or plane called the image layer ([5], p. 175). In classic radiography, the entire thickness of the object between the focal spot and the film is seen on the film in two dimensions. Therefore, images of structures at different levels are superposed on each other.

In tomography, the images of the structures at different levels are prevented from overlapping and only the layer whose image is desired is examined. The parts in front of and behind this layer become blurred.

The image layer is an invisible layer in space between the radiation source and the image receptor. The image layer is a 3-dimensional "focal trough" and the dentition and related structures must be positioned within this layer in order to be clearly seen in the panoramic radiography [1]. The structures outside of this layer are seen as blurry, magnified or smaller than normal and distorted ([5], p. 177).

## 4.4 Technical Considerations of Panoramic Radiography

### 4.4.1 Image Layer (Focal Through)

The image layer is an invisible layer in space between the radiation source and the image receptor. The image layer is a three-dimensional "focal trough" and the dentition and related structures must be positioned within this invisible layer.

The structures outside of this layer are seen in the image that is blurry, magnified, or smaller than normal and distorted [6] (Fig. 4.4).

### 4.4.2 Projection Geometry

Projection geometry explains the effect of the size and position of the focal spot point on image clarity, distortion, and magnification ([5], p. 46).

#### 4.4.2.1 Image Resolution

Resolution describes the sharpness of the boundary between two different radiodensity fields. Although the sharpness and resolution of the image have different properties, they are affected by the same geometric variables. For a correct clinical diagnosis, the radiography should be taken under high resolution and optimized conditions.

In order not to lose resolution and improve image quality;

1. *Focal spot point*: The focal spot point used in dental X-ray devices should be ≤1 mm. The larger the focal spot point, the less clear the image.

**Fig. 4.4** Representative İmage of focal through

2. *Distance between object-focal spot point*: The greater the distance between the object-focal spot point, the more image blur is reduced.
3. *Distance between object and film*: The shorter the distance between the object and the film, the better the image clarity [1].

#### 4.4.2.2 Distortion

Distortion is formed as a result of magnification at different points of the same object. This is because all parts of the object are not equal to the same focal spot point-to-object distance.

**If it is not equal, distortion occurs in two ways;**

1. *Shortening*: It develops due to unequal distances between different parts of the object and the film.
2. *Elongation*: Elongation occurs when the X-ray focus is passed through the right corner of the object, not directly onto the film.

**Things to do to minimize distortion;**

- The film should be positioned parallel to the long axis of the object. When the long axis of the film and tooth are parallel, the deformation in the image is minimized.
- It should be ensured that the central X-ray is perpendicular to the film and object. The film and the object are parallel to each other, but if the X-ray is not perpendicular to them, distortion occurs in the image. In cases where X-rays are sent vertically but at an angle, the palatinal roots of the teeth are seen to be longer than the buccal roots ([5], p. 46).

#### 4.4.2.3 Magnification

Magnification means obtaining an image larger than the actual size of the object in radiography. The passing of photons in different ways causes the image on the radiography to grow. Magnification is related with the focal spot point-film distance and object-film distance. When the distance between the focal spot point and the film is increased and the distance between the object and film is decreased, the image undergoes magnification.

### 4.4.3 Digital System Detectors

Digital imaging is a filmless imaging system. Unlike conventional imaging systems, they do not require film and bath solutions. Instead, it uses a sensor and computerized imaging method that instantly creates an image on a computer screen.

#### 4.4.3.1 Charge Couple Device (CCD)

It was first introduced to dentistry for intra-oral imaging in 1987. The system was created by Dr. Frances MOUYENS and the Trophy company launched it commercially for the first time.

CCD uses a thin silicon layer. Images are recorded with this silicon layer. Silicon crystals are arranged within a pixel.

When exposed to radiation, the bonds between silicon atoms are broken and form electron-gap pairs. The number of these gaps is directly proportional to the amount of radiation coming from the X-ray source.

The resulting electrodes are then drawn towards the most positive part of the device. Here they form electron packets called charge or charge packets. Each packet corresponds to one pixel. Here, these charge packets made up of each pixel (one pixel in the matrix) form the latent image. The image is created by transferring each pixel one after another in sequence. When the charge (load) reaches the end of the row, a reader is supplied to the amplifier and transmitted as a voltage to the ADC.

For panoramic imaging, CCDs (charge couple devises) of several pixels wide in either linear rows or one dense pixel length (one row) were produced.

#### 4.4.3.2 CMOS (Complementary Metal Oxide Semiconductor)

CMOS forms the basis of typical consumer video cameras. These detectors are silicon-based semiconductors, but technically the way pixel charges are processed is different from CCD. Each pixel in the sensor is directly connected to the neighboring pixel via the transistor.

As in CCD, electron gaps due to X-ray are created depending on the amount of incident beam. These charge packs are transferred to the transistor as small voltages. The voltage across each transistor is sensed, read, and assigned a shade of gray just like the CCD. CMOSs are widely used today as chips and video camera detectors and are cheaper ([5], p. 213).

#### 4.4.3.3 PSP (Phosphorus Plate System)

Photostimulable phosphor plates absorb and store energy from X-rays and then release this energy in the form of light (phosphorescence) by stimulation of another suitable wavelength of light.

The amount of X-rays absorbed by the object and the amount of light emitted into the phosphorescent is directly proportional. The material used in phosphor plates is barium fluorohalide containing europium.

In combination with metals such as barium, iodine, chlorine, bromide, it creates a crystal lattice. The addition of Europium creates a space in this weave. When irradiated with X-rays, electrons in the europium absorb energy and are displaced. These electrons migrate into nearby halogen spaces (called f centers), into the fluorohalide lattice and remain there in a metastable state. The number of electrons remaining here increases in proportion to the X-ray value and forms a latent image. Excitation with red light at the rate of 600 nm releases barium fluorohalide electrons. Electrons return to europium. During this turn an energy is released from the 300–500 nm green spectrum. This energy is captured by photomultiplier tube and converts light into electrical energy. The resulting voltage occurs according to the changes in the light coming from the latent image. The voltage signal is digitized with an analog–digital converter and displayed as a digital image ([5], p. 224).

PSP systems can be used for panoramic viewing. The PSP systems named below are used most frequently.

- *Fixed scanning system*: These systems have preferred to reflect red laser light with a versatile separate system. There is a mirror inside the system. When the mirror rotates, laser light passes through the plate, and as the plate advances, scanning occurs on the adjacent phosphor plate.

- *Rotating plate system*.
- *Photon collection system*: In this system, the scanner laser beam rotates instead of plates. It has a resolution of up to 20 lp/mm and 16 bits and about 65,000 gray tones were targeted at 40 lp/mm as an achievable technology ([5], p. 225).

#### 4.4.3.4 Flat Panel Detectors

It is mostly used in the field of medicine and is now being used as routine in extra-oral imaging devices. These detectors create larger matrix areas with a pixel size of less than 100 µm. They can be used for these larger areas, especially head and neck examinations.

In these detectors, there are two approaches to X-ray sensitive material selection. Indirect detectors: They are sensitive to visible light and are used to convert an amplifying X-ray energy into light. The detector thickness of these devices is limited. The display size of thick screens is small, but as they absorb more photons, the image sharpness decreases.

This material is similar to selenium silicon, and its atomic number is higher than similar materials. The higher the atomic number, the more effective X-ray absorption.

The electrons released by the electric field effect (during selenium irradiation) are directly sent to the thin-film detector located at the bottom. Selenium is generally used in direct detectors, they provide very high resolution, their efficiency is less than the indirect. Electrical energy is directly proportional to X-ray power. Energy is processed and turned into an image by applying appropriate rows and columns. It is an expensive system, but it is used in specialized imaging procedures or devices such as digital panoramic and CBCT ([5], p. 240).

### 4.4.4 Digital Detector Features

#### 4.4.4.1 Contrast Resolution

Contrast resolution is the difference in density in the radiographic image. This depends on the X-ray absorption characteristic of the imaged tissue, the capacity of the image receptor, the capacity of the computer to display them, and the ability of the examiner to notice them.

Current digital detectors can capture 8-10-12 or 16 bit deep data. Since the bit depth is a multiple of 2, theoretically detectors can capture 65,536 different density. However, in practice, the real number is limited by the errors in image formation, which is called noise. Regardless of how much gray difference a detector will catch, conventional computer monitors can only display an 8-bit gray scale. Therefore, the density that can be monitored on a monitor is 256.

Another limitation is that the human eye can detect only 60 shades of gray under favorable conditions. If this radiography examination is not suitable, it falls below 30.

#### 4.4.4.2 Spatial Resolution

Spatial resolution is the capacity to separate fine details. Theoretically, pixel size in digital imaging systems limits resolution.

Currently, the highest CCD resolution is 20 µm. Approximately 25 lp/mm can be achieved at 20 µm/pixel. Observers can easily distinguish 6 lp/mm without any magnification. 20 lp/mm is usually what can be observed in a conventional intra-oral film. Current digital systems, on the other hand, can show a resolution of 8–12 lp/mm.

#### 4.4.4.3 Detector Sensitivity

Detector sensitivity is the ability to respond to lower radiation. The sensitivity of digital receptors is not fully standardized. It is affected by a number of factors. Detector efficiency varies with pixel size and system image ([5], p. 231).

#### 4.4.4.4 Image Processing

Image processing is the name given to the enhancement, analysis, processing, and modification processes made on a digital image. There are many processing methods available in dental digital imaging. Some of these processes come automatically in image processing software. Others are under the control of the operator.

#### 4.4.4.5 Image Storage

The use of digital images in dentistry requires image archiving and examination systems. The storage of images can most simply be done on magnetic or disk media. However, the problem arises in what format and how the images will be stored in these processes. Generally, digital imaging can have a data size of 200 kB to 6 MB (extraoral images). The storage of these data is not a trivial matter at all. However, the important issue should be in a way that prevents deletion or modification of the original image data of the software, since digital images are stored in digital format. Not all software is suitable for this. Therefore, it is attempted to be made a standard. However, image storage should generally be done on hard-disks, CD and DVD's.

#### 4.4.4.6 Image Compression

The purpose of image compression is to reduce the size of the image (for archive and transmission). This becomes a big problem, especially in busy clinics that store extra-oral images, because storing data can take up a lot of space. Compression refers to the meaningful compression of data without loss of image information. Compression methods are expressed as lossy and lossless. There is no loss in image data in the lossless method. Many compression techniques take advantage of removing the excess in the image. It creates the same but simpler regions. The maximum compression ratio is typically 1/1 for lossless compression. However, in lossy compression, image data is compressed more.

Studies have shown that these compressions generally do not affect image quality. A noticeable effect on 12/1 and 14/1 compression has not been found, especially for the diagnosis of caries. In endodontic treatment, for canal length calculations, 25/1 is the same rate of diagnostic as uncompressed images. Generally, the simplest compression technique is the JPEG compression method. Apart from that, the JPEG 2000 format is one such image compression technique. Its main difference is that it prevents blurring that occurs at high compression value in JPEG ([5], p. 240).

## 4.5 Major Concerns in Panoramic Imaging

**Advantages of Panoramic Imaging**

- Comprehensive display of facial bones and teeth.
- Minimal radiation dose application.
- Patient positioning.
- Providing convenience for the patient in examination.
- It enables us to easily take radiography in patients with mouth-restriction.
- Short duration.
- Useful in informing patients.

**Disadvantages of Panoramic Imaging**

- Low image quality compared to intra-oral radiographs.
- Shadows created by soft tissues and the airway.
- Ghost images and artifacts.
- Distortion and magnification.
- Long exposure time.

In addition, the main disadvantage of panoramic imaging is that it is not suitable for children under 5 years of age and disabled people due to the long exposure time ([4], s. 172). The development of superpositions on the approximal surfaces of premolar teeth is another disadvantage of panoramic. Sometimes the superposition of cervical vertebrae hides odontogenic lesions, especially in the anterior region.

## 4.6 Patient Positioning

Position of the patient is very important in panoramic radiographs. To obtain diagnostically useful panoramic radiographs, it is necessary to prepare patients properly and to position their heads carefully in the focal through. Teeth and dental arches must be in the image layer. In this way, the image is obtained with the least distor-

**Fig. 4.5** Figure showing the correct positioning of the patient in panoramic imaging

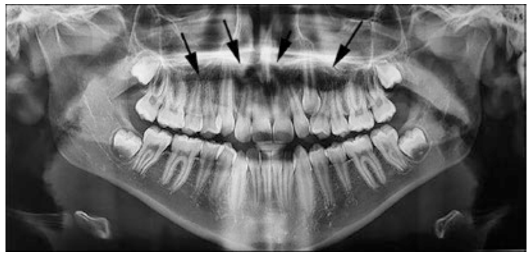

**Fig. 4.6** Figure showing the patient's tongue does not touch the palate, resulting in the formation of a radiolucent band that shadows the apices of the maxillary teeth (arrows)

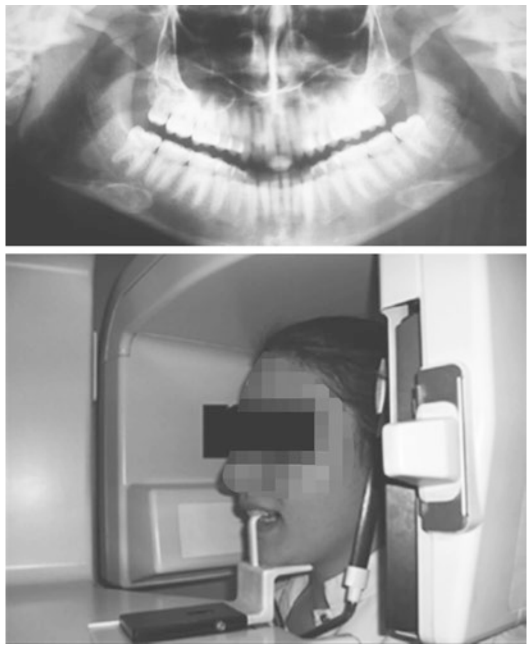

**Fig. 4.7** The patient bites the bite block forward so that the notch is inside the mouth, both dental arches and teeth remain outside of the image layer. In the radiographs taken in this position, all of the front teeth are blurred, but the premolars are superposed on each other

tion [1]. If the patient is wearing glasses, they should be asked to remove their glasses, as well as all jewelry and other metallic items ([4], p. 166). After the machine settings are made in orthopantomography, the patient puts his chin on the support so that the patient's Frankfurt plane is parallel to the ground and the sagittal line is in the middle of the chin support [1]. The patient should be informed about how to bite the bite block, then he should be told to close his lips and swallow and stick his tongue to the palate [6]. After the patient is placed on the cephalostat in this way, he is asked to take a step forward and hold the holders on the machine with his hands. This position is called skiing position [1]. During the irradiation period, he should be told to keep his tongue on his hard palate and not to move at all ([4], p. 166) (Fig. 4.5).

### 4.6.1 Common Errors in Panoramic Radiography

Positioning errors do not depend solely on the patient or the person taking radiography, there is a need for devices designed to facilitate patient positioning.

During irradiation, the patient's tongue does not touch the palate, resulting in the formation of a radiolucent band that shadows the apices of the maxillary teeth and overlook periapical pathological lesions, root resorption, and non-odontogenic lesions close to the apex of the maxillary teeth [7] (Fig. 4.6).

If the patient bites the bite block too far forward so that the notch is inside the mouth, both dental arches and teeth remain outside of the image layer. In the radiographs taken in this position, all of the front teeth are blurred, while the premolars are superposed on each other (Fig. 4.7). If the patient has bitten the bite block from behind, the anterior teeth are also blurred but wider (Fig. 4.8) [1].

When the patient's head is tilted too low (Fig. 4.9), excessive inclination in the occlusal

**Fig. 4.8** The patient has bitten the bite block from behind, the anterior teeth are also blurred

plane, blurring of the apex of the mandibular anterior teeth, narrowing of the intercondylar distance, sometimes inability to trace the condyle heads, and superposition in the posterior contacts of the teeth can occur [7].

When the patient's head is tilted backwards (Fig. 4.10), too much, the upper incisors will stay out of the image layer, so these teeth appear blurry. As a result of the superposition of the hard palate on the roots of the teeth, a radiopaque line forms on the apex of these teeth. In addition, condyles protrude towards the edges of the film.

If the sagittal line deviates from the midline to the right or left, that is, if the head turns to the right or left, the teeth and dental arches on one side give a wider image than the other side (Fig. 4.11). During the radiography, the neck of the patient should be stretched well, in which the patient should be given a ski position. If this position is not given, the ghost image of the vertebrae cannot be prevented and as a result, a radiopaque

**Fig. 4.9** When the patient's head is tilted too low. excessive inclination in the occlusal plane, blurring of the apex of the mandibular anterior teeth

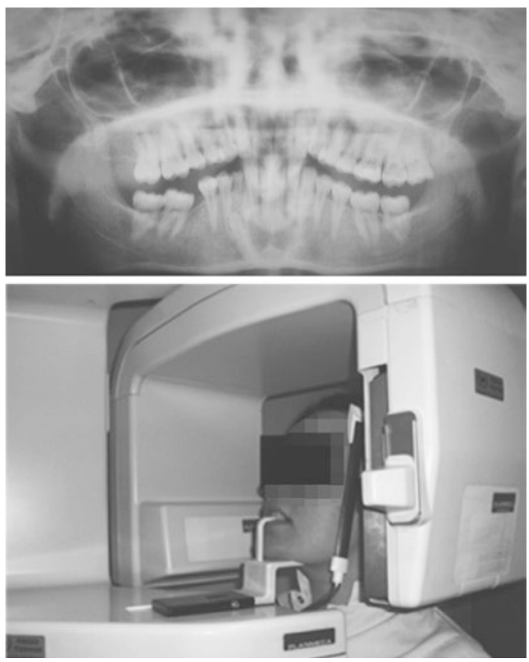

**Fig. 4.10** When the patient's head is tilted backwards too much, the upper incisors will stay out of the image layer, so these teeth appear blurry

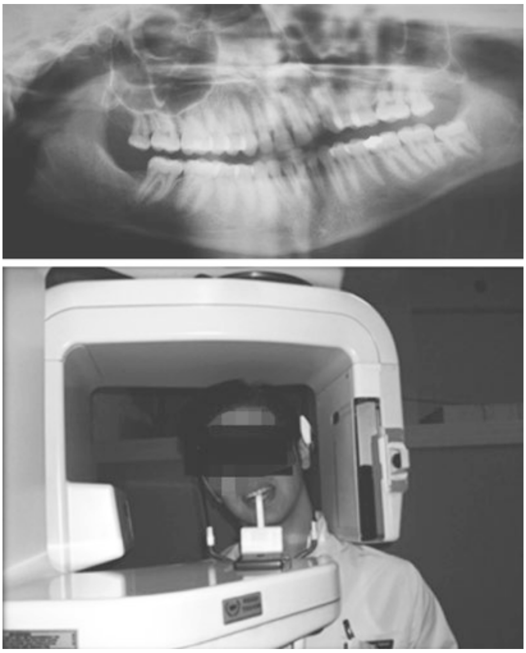

**Fig. 4.11** If the sagittal line deviates from the midline to the right or left, that is, if the head turns to the right or left, the teeth and dental arches on one side give a wider image than the other side

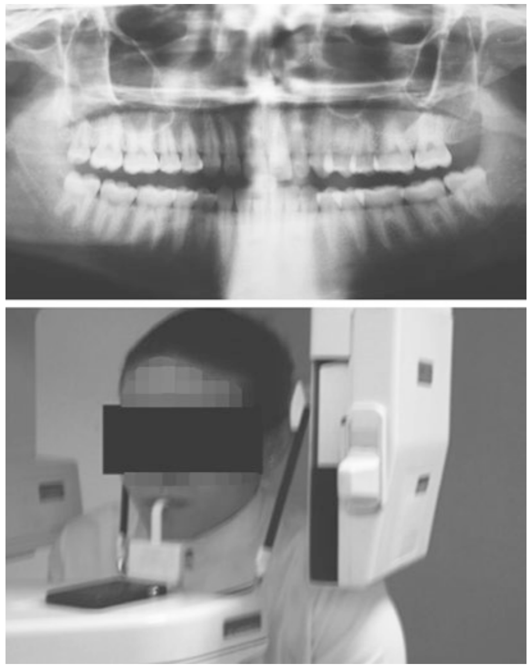

**Fig. 4.12** During the radiography, the neck of the patient should be stretched well, in which the patient should be given a ski position. If this position is not given, the ghost image of the vertebrae cannot be prevented

area is seen in the middle of the radiographs (Fig. 4.12). During the radiography, after the patient is positioned, it is requested not to move during the exposure. If patient moves, irregular parts occur on the radiography [1].

#### 4.6.1.1 Ghost Images

- Cervical vertebra (CV),
- Corpus of the mandible, ramus, and contralateral shadow of its angulus (Md),
- Hard palate (PI) ([4], p. 161).

In fact, many ghost images originate from normal anatomical tissues. Although ghost images caused by some anatomical formations cannot be prevented, most ghost images can be eliminated or reduced. The most common ghost image, which we do not want to occur, is the image formed by the vertebrae in the mandibular incisor region. In order to prevent this, the patient should stabilize his neck straight and stretched during the irradiation. If the patient stands hunched over, the X-rays will cross the cervical vertebrae transversely, so it is seen as a radiopaque shadow in the mandibular incisor area ([4], p. 174).

Since all jewellery, especially earrings have high atomic density and are generally outside the image layer, they cause ghost images. The ghost image of the earrings usually occurs on the maxillary sinus and on the opposite side of the mandible corpus.

If the earring is unilateral, the ghost image of it can be mistaken for an odontoma or another radiopaque lesion. The earrings on the tongue are seen in the form of a radiopaque shadow on the nasal passage. Its actual shadow changes according to the position of the tongue during the irradiation (Fig. 4.13).

In cases where the X-ray device is well calibrated, the use of lead apron, which we use to protect the patient from radiation, has been abolished in many countries. Lead aprons and thyroid protectors are used to protect patients from incoming radiation.

Objects outside of this focal trough that are dense enough to attenuate X-rays will occasionally present twice as the X-ray tube rotates around the patient, this is known as a ghost image. The density will appear at the true location and secondly on the contralateral aspect of the image as a distorted "ghost" image. Motion artifact is a patient-based artifact that occurs with voluntary or involuntary patient movement during image acquisition (Figs. 4.14 and 4.15). Metallic objects esp. Thyroid collars, except aluminum, are opaque, and most animal bones and all glass foreign bodies are opaque on radiographs. Most plastic and wooden foreign bodies (cactus thorns, splinters) and most fish bones are not opaque on radiographs (Figs. 4.16 and 4.17).

Hoogeveen et al. compared newly developed cephalographic thyroid protectors (CTP) and anatomical cranial collimators (ACC) with traditional thyroid collars. In the study, four separate patient groups were formed, in which nothing was used, CTP was used, CTP + ACC was used together, and a thyroid protective collar was used. As a result, while the radiation dose affecting the thyroid was reduced by 85% when groups 2 and 3 were used, an 81% reduction occurred by using only group 4 [8].

Prostheses of the patient must also be removed during panoramic radiography. Apart from this, if our patient is wearing glasses, he/she should definitely remove it as it may hide important details on the image ([4], p. 170).

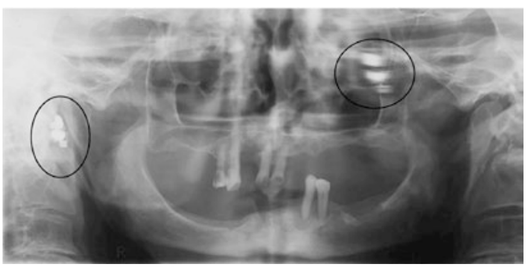

**Fig. 4.13** The image of a duplicate 'ghost' image at the contralateral aspect of the image

**Fig. 4.14** The image of a motion artifact of the patient

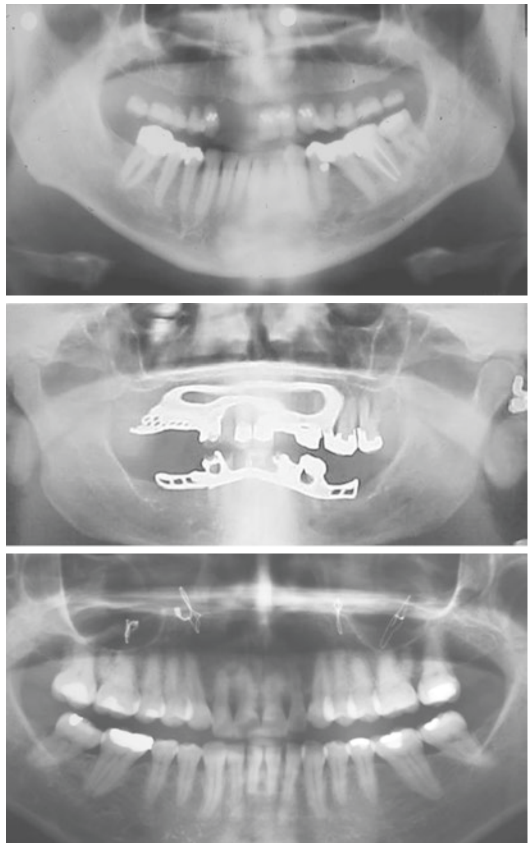

**Fig. 4.15** The image of a motion artifact of the pediatric patient

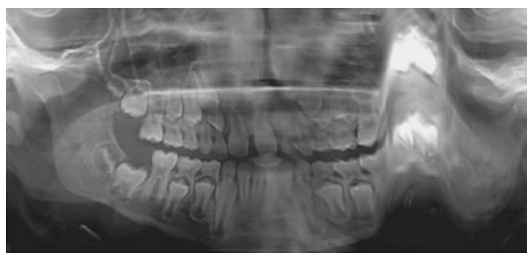

**Fig. 4.16** The panoramic images of foreign bodies and motion artifact that appear on the radiographs

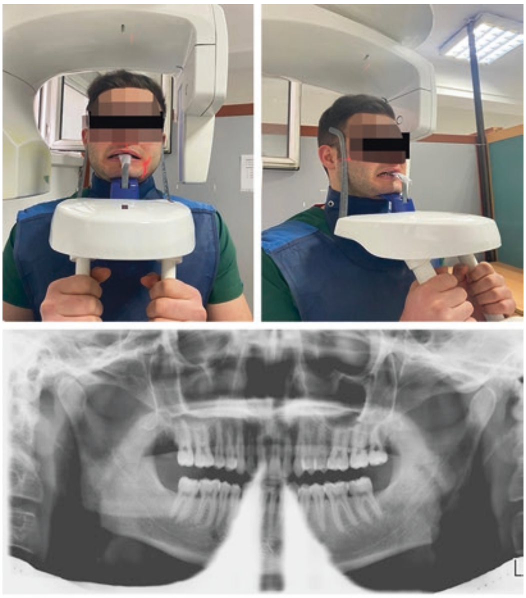

Fig. 4.17 The artifact image of a due to thyroid collar

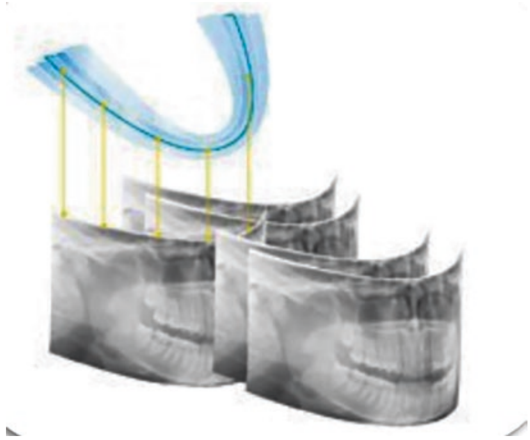

Fig. 4.18 The principle of creating images (using the best sections) from multiple sections of volumetric panoramic image reconstruction

## 4.7 Advances in Panoramic Imaging

### 4.7.1 Volumetric Panoramic Reconstruction

Volumetric panoramic radiography provides the opportunity to create an advanced panoramic image in each section within the focal through area and in its combination. Although volumetric panoramic radiography varies according to the device, 5–8 different sections can be created from a single scan. It provides the opportunity to obtain higher quality images with the same radiation dose and in the same time as conventional panoramic radiography.

With this technique, the superposition section is eliminated with the help of a computer, it is based on the principle of creating images (using the best sections) from multiple sections, not a single section (Fig. 4.18).

## 4.8 Panoramic Radiography: Radiation Dose

Depending on the dental radiography, we also observe that the stochastic effects depending on the age. It has less effect in the elderly, mostly in children and young people. When calculating the likelihood of cytocratic effects, it should not be forgotten that individuals under 10 years of age are affected three times more, individuals between 10 and 20 years 2 times and individuals 20–30 years 1.5 times more [9].

Table 4.1 shows the effective radiation dose obtained from dental radiographs used in dental practice, calculated according to the ICRP 1990 norms. Studies conducted in recent years are carried out especially according to the ICRP 2007 criteria. According to ICRP 2007 criteria, it has shown that the amount of radiation dose revealed as a result of dental radiography is higher than ICRP 1990.

Although dental radiography applications give less radiation dose than other medical applications, a verification process should be passed to

**Table 4.1** Effective radiation doses obtained from dental radiographsm (ICRP 2007)

| X-ray techniques | Effective dose (mSv) | Fatal cancer rate |
|---|---|---|
| Intraoral Radiographies (Periapical-Bitewing) | 1–8.3 | 0.02–0.06 |
| Maxillary Anterior Occlusal | 8 | 0.4 |
| Panoramic | 3.85–30 | 0.21–1.9 |
| Lateral Cephalometric Radiography | 2.0–3.0 | 0.34 |
| Sectional Tomography (each section) | 1–189 | 1.0–14.0 |
| CT scan (Maxilla) | 364–1202 | 18.2–88 |
| CT scan (Mandible) | 100–3324 | 8–242 |

determine whether the specific requirement is really needed or not.

The most important step of this is the selection criteria for patients to be radiographed. Selection criteria are based on multiple factors.

Radiographic examination decision should always be made as a result of anamnesis and clinical examination. The indication and technique appropriate for the patient should be determined. Whether the patient has had a film before and the film has not lost its validity for diagnosis, the use of previous radiographs can also be considered among the selection criteria [9].

Currently, many companies around the world produce high quality films and digital panoramic machines. Nowadays, panoramic devices are multi-rotation centric devices. Panoramic devices can create images of the patient in different positions and localizations, instead of providing only standard panoramic images.

These devices can provide tomographic images of TMJ, maxillary sinuses, and cross-sectional views of maxilla and mandible. Cephalometric radiographs can be easily taken with the same device. Today's devices also have computer controlled automatic dose control, motion speed control, and versatile tomography capabilities. In purchasing these devices with different features, the need of the physician or imaging center and also the effective dose given to the patient should be considered.

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