Examination Strategies

The term "examination strategy" stands for the rational selection of proven radiographic examination methods, depending upon the particular indication, in order to avoid unacceptable radiographs and unnecessary radiation exposure. Today it can already be stated that the use of panoramic radiography is mandatory in the following cases:

- Initial examination of new patients in all age groups (including orthodontic and periodontal patients)
- Early diagnosis of developmental anomalies of the dental apparatus (recommended especially at ages 10, 15 and 20) to check the dentition and to diagnose early any odontogenic cysts and tumors
- To clarify the cause of missing teeth
- Radiographic examination of nonvital teeth
- Suspicion of odontogenic diseases of the sinuses
- Temporomandibular joint disturbances caused by malocclusion (in such cases, a panoramic radiograph should be taken with the patient in habitual occlusion)
- Asymmetries of the face and the jaw
- Pressure sensitive, painful as well as asymptomatic swellings
- Poorly healing extraction wounds and suspicion of osteomyelitis
- Examination of nonodontogenic cysts, tumors and tumor-like lesions
- Suspicion of intraosseous or invasive growth of tumors, and suspicion of metastasis
- Paresthesia of the mandibular nerve
- Examination of systemic diseases and syndromes
- Maxillofacial fractures, and suspicion of fracture following trauma
- Before and after the performance of surgical interventions

It is self-evident that before taking a panoramic radiograph of a new patient, the dentist must request from the previous dentist any already available radiographs, in order to reduce radiation exposure and keep the cost to a minimum.

The recognition that only a panoramic radiograph provides a complete and perfect tool for the initial examination is leading to the acceptance of a new strategy for radiographic examination, where the goal is to reduce costs and reduce patient exposure to ionizing radiation. In this strategy, individual radiographs are viewed as special and supplemental.

This strategy evolves from the panoramic film; this is the basic radiograph, which can be classified into four diagnostic regions:

**Dentoalveolar region** (Fig. 1)
**Maxillary region** (Fig. 2)
**Mandibular region** (Fig. 3)
**Temporomandibular joint region** (including the retro- maxillary and cervical region) (Fig. 4)

Any supplemental special radiographs that may be necessitated by the situation can be taken in the dental office if appropriate equipment is available, otherwise the patient should be referred to a radiology clinic.

**Special Radiographs for Examination of the Dentoalveolar Region** (Fig. 1)
Depending upon the situation, supplemental radiographs of the following types may be indicated:

- Bite-wing radiographs for caries diagnosis
- Periapical dental radiographs for examination of periapical lesions and endodontic problems
- Dental radiographs for periodontal diagnosis (depiction of the root apex is not always necessary)
- Dental radiographs and possibly occlusal radiographs to determine position in cases where localization is difficult

These radiographs can be taken with virtually any dental X-ray equipment.

**Special Radiographs for Examination of the Maxillary Region** (Fig. 2)
Depending upon the situation, supplemental radiographs of the following types may be indicated:

- Occlusal radiographs of the maxilla, e.g., for depiction of pathologic structural detail, depending on the indication
- Cephalometric radiographs using lateral and posteroanterice projection, e.g., for problems of localization in the maxilla
- Water’s projections of the facial skeleton with maximum jaw opening, e.g., for examination of the maxillary sinuses in cases of dentogenic involvement
- Tomography and computed tomography
The four diagnostic regions in panoramic radiography

1. **Dentoalveolar region**
   To complement the panoramic radiograph, in specific situations occlusal radiographs or periapical films precisely positioned with a film holder are employed.

2. **Maxillary region**
   Depending upon the demands of the case, occlusal films and skull films made with conventional or more modern imaging procedures may be required to supplement the panoramic radiograph.

3. **Mandibular region**
   In addition to occlusal radiographs, the mandibular posterior-anterior radiograph (reverse Towne projection) best serves to depict the anterior segment. In special cases, the "unilateral mandibular" technique or computed tomography may be employed as appropriate to complement panoramic radiography.

4. **Temporomandibular joint region, including the retro-maxillary and cervical regions**
   For more detailed study of the temporomandibular joint, spiral tomography and especially computed tomography and magnetic resonance imaging are used in addition to conventional radiographic methods. Furthermore, arthrography and arthroscopy may be employed as intervention techniques.
Occlusal radiographs can be taken with any X-ray equipment. Cephalometric and Water's projections of the facial skeleton can be taken in the dental practice only if the panoramic radiography equipment features the additional cephalometric attachments. However, some cases should be referred to specialists in a radiology clinic because the equipment there usually provides a reduced level of radiation exposure and reduced cost. Generally speaking, conventional projection techniques and even tomography are being replaced for the most part today by the improved possibilities for resolution offered by computed tomography (CT).

Special Radiographs for Examination of the Mandibular Region (Fig. 3)
In certain cases, additional radiographs of the following types may be indicated:

- Occlusal radiograph of the mandible, e.g., to depict pathologic structural details, cysts, fractures and for localization
- Mandibular posteroanterior radiograph (reverse Towne) with maximum jaw opening for frontal depiction of the temporomandibular joints and the ascending rami, and for localization of atypically impacted third molars (also in the maxilla)

All types of occlusal radiographs can be taken with dental X-ray equipment. The reverse Towne radiograph can be taken in the dental office only with panoramic equipment that has a cephalometric attachment.

In some cases (see above), however, it may be prudent to refer the patient to a radiology clinic. Examination of the mandibular region by means of conventional radiographic technique and conventional tomography is also being replaced for the most part today by CT, except in patients with metal implants and metal bridge-work, which cause artifacts.

Temporomandibular Joint Region Including the Retromaxillary and Cervical Region (Fig. 4)
Depending upon the situation, supplemental radiographs of the following types may be indicated:

- The temporomandibular joints can be examined using noninvasive or invasive methods. The noninvasive technique begins with an axial skull film to determine the angle of the condylar axes to the median sagittal plane.
- Subsequent films consist of radiographs as described by Schüller.
- These may, however, also consist of a series of lateral and frontal tomographs.
- Furthermore, for temporomandibular joint alterations that exhibit a density similar to that of bone, CT with the bone window can be used; for the depiction of soft tissue (TMJ disc) the soft tissue window is selected.
- In special cases nuclear spin tomography or magnetic resonance imaging offer additional possibilities for noninvasive depiction of the TMJ disc.
- Interventional radiology of the temporomandibular joint continues to defend its position using arthroscopic and arthrotomographic methods.
- Today, the depiction of saliva glands is still frequently accomplished using sialography, despite competition from computed tomography. In addition to panoramic radiography, the lateral jaw projection can be used to depict the parotid gland. The mandibular posteroanterior survey is used to depict the parotid gland in its frontal plane.
- The examination of the stylohyoid chain and the hyoid bone is usually performed today by means of a low energy projection with lateral jaw exposure, even though computed tomography provides particularly good depiction of the hyoid bone.

Conventional skull radiographs such as the axial projection and the Schüller projection can also be prepared in the dental office if appropriate equipment is available. However, for the reasons already mentioned above it is often wise to refer such cases to special radiology clinics that are also able, if necessary, to extend the examination using other modern possibilities of radiographic technology. Arthroscopy and arthrography employed with conventional tomography (arthrotomography) must be performed under sterile conditions exclusively by specialists, who can also provide appropriate interpretation. Similarly, the indication for sialography and hyoid bone radiographs occurs only seldom in the dental practice and should therefore also be referred.

Rational radiographic examination should be performed following a well-considered plan, as presented in the suggestions above, because in this way the necessary examinations can be accomplished with a minimum of effort and expense. Radiation exposure can be kept to a minimum. For this reason, it is justified to speak here of “active radiation protection.”
Panoramic Radiography for Basic Information and Special Radiographs for Supplemental Examination
Technique for Panoramic Radiography

It is not possible in the scope of this book to describe the special radiographic technique of panoramic radiography with regard to all of the different equipment that is available today. On the other hand, it is possible to present general guidelines that apply equally to all apparatus. The clinical photographs that were used to portray the technique show the Orthopantomograph 10 S and the versatile Orthophos from Siemens Co.

Optimum interpretable radiographs can only be achieved with a carefully performed radiographic technique. Only a profound knowledge of the technical possibilities and limitations will permit the creation of acceptable radiographs, even under extraordinary circumstances. An unsystematic “search” according to one’s own spontaneous ideas rarely leads to success, but often to unnecessary additional radiation exposure.

In addition to the normal panoramic radiograph, many of the instruments available today can also be used to prepare conventional radiographs of the facial skeleton. This opens for the specialist and the interested general practitioner many new diagnostic possibilities and insights into broader relationships, which had not been accessible previously. Based on the experiences with cephalometric technique, the radiography industry has employed modern X-ray and generator technology, as well as new film-foil combinations and digital computers to create solutions that seemed unattainable only a few years ago.

Panoramic radiographs, which permit the use of various zonography programs on the reclined patient, must nevertheless be reconciled to special clinics because of the extraordinary costs in terms of space and equipment. An example in this regard is the Zonarc-R (Palomex, Inc.).

A new version of panoramic radiography is the Scanora R developed by E. Tamminen. Such equipment permits, in addition to numerous zonography programs, the preparation of spiral tomography with a seated patient for depiction of the temporomandibular joint or cross sections of the jaw. This instrument, too, is generally limited to special diagnostic centers or larger group practices because of the high cost. In the near future, equipment for producing digitized radiographs will also be common in the dental practice.

This chapter provides only a momentary overview of today’s possibilities; the development of the technology continues at a rapid pace, and we stand today only at the start of the development in this field. For this reason, we will present primarily generally applicable radiographic technical rules.
Technique for Panoramic Radiography

In the late 1940s, Paatero developed the fundamentals of panoramic radiography from the principles of tomography. Three peculiarities characterize classic tomography:

- The movement in opposite directions of the X-ray and the film around the object determine the degree of elimination of undesired structures located outside the in-focus layer.
- The thickness of the in-focus layer depends upon the angle between the layer to be examined and the central ray.
- The choice of the layer position is achieved by shifting the center of rotation of the system.

Derived from these principles, panoramic radiography is characterized by the following:

- X-ray source and film holder move clockwise around the approximately elliptically shaped dental arches.
- Structures close to or distant from the film, as well as the thickness of the in-focus layer are determined by the relationship of the speed of the film cassette (mounted on the film holder) to the speed of the X-ray source.

5 Location of the average position of the central in-focus layer, projected onto the mandible
The layer can be reduced (-) for children or enlarged (+) for adults as necessary.

6 Layer thickness
The field that is projected onto the left mandible exhibits the layer thickness for a normal case. X-ray source and film cassette rotate around the centers of rotation.

7 X-ray projection and "column" of the centers of rotation, viewed laterally
Dashed line indicates the "column" of the centers of rotation; the colored area represents the in-focus layer in the anterior region.

8 X-ray projection and fulcrum point, viewed dorsally
Dashed line represents the centers of rotation; the colored field is the in-focus layer in the right molar region. The object-film distance is longer in the maxilla because of the position of the central ray in relation to the plane of the film.

Advantages of panoramic radiography

- Presents a comprehensive dental examination by means of a panoramic representation of the masticatory system, including the temporo-mandibular joints and the maxillary sinuses.
- Permits detection of functional and pathologic relationships and of their effects on the masticatory system.
- Provides a documentary overview for treatment planning and follow-up.
- Reduces radiation exposure by means of a rational examination strategy.
With increasing speed and simultaneous increase in layer thickness, the plane is displaced and reversed toward the film and away from the center of rotation.

The characteristic vertical slit plane that is mounted on the case and in front of the film eliminates any scatter radiation.

The vertical, millimeter-wide ray creates three imaginary points of rotation if the course of the X-ray beam is viewed in a horizontal cross section (three-point procedure of Paatero). These imaginary centers of rotation are generally referred to as the functional focus; in reality, when considered in space these are in fact moving rotation center columns leaning inward. These columns that move during the exposure always remain perpendicular to the central ray and therefore determine the angle of inclination of the in-focus layer vis-à-vis the vertical, depending upon the established angle of the X-ray source.

9 Temporomandibular joint, frontal
This schematic depicts the positioning of the X-ray head and the film cassette for frontal tomography of the right temporomandibular joint.

10 Temporomandibular joint, lateral
Shown here is the positioning and movement of the X-ray source and the film cassette for lateral tomography of the left temporomandibular joint.

11 Distortion of the front teeth
Front teeth that are located anterior to the in-focus layer appear reduced in size, while teeth behind the layer appear enlarged.

12 Distortion of a round body
Any round object that resides within the in-focus layer will be projected as a round object. A round body that is away from the layer will appear enlarged and flattened while an object near the film will be vertically oval and reduced in width.

Disadvantages of panoramic radiography
- Extreme class II and III anterior tooth relationships make it impossible to depict optimally the maxillary and the mandibular anterior segments simultaneously.
- The ratio of the focus-object distance to the object-film distance is not everywhere identical, resulting in a varying enlargement factor.
- Precise measurements are not possible.
- Structures that reside outside of the in-focus layer may be superimposed upon the normal structures of the jaw and mimic pathology.
Positioning of the Patient in the Apparatus

Correct positioning will determine the quality and the interpretability of the final radiograph.

The patient should be asked to remove eyeglasses, contact lenses, jewelry and, in some cases, dental prostheses (see p. 22).

The correct position of the collimator on the skin should be checked in the mirror. (Be careful with patients who have beards!) The position of the occlusal plane and the arrangement of the median sagittal plane of the occipital region of the head should be checked. The following step-by-step procedure is recommended:

- Wash hands and apply gloves and mask in view of the patient
- Explain the movement of the film cassette and the X-ray head
- Explain the bite holder and insert the film cassette
- Select the proper exposure data
- Apply the lead apron for panoramic radiography
- Have the patient practice protrusive mandibular positioning and tongue position
- Explain to the patient the proper body position in the apparatus

13 Orthophos
Thanks to modern technology, the Orthophos from Siemens permits adjustments for especially narrow or wide dental arches, sinus radiographs, survey films and special projections for third molars as well as TMJ views in both lateral and frontal planes.

14 Patient correctly positioned in the Orthophos
Clearly visible is the collimator and the stable arrangement of the cephalostat. This apparatus employs a handy flat cassette.

15 Cephalostat and bite positioning aid
The robust construction of the cephalostat is a prerequisite to guarantee symmetrical positioning. The cephalostat automatically adjusts for any skull size.

16 Cephalometric attachment
This component of the apparatus permits not only the preparation of lateral cephalometric films but also the preparation of the most important standard skull projections in the standard positions of radiology.

Several modifications of patient positioning for special indications include those:
- for children in the mixed dentition age, for depiction of tooth buds or supernumerary teeth in the maxilla (p. 19)
- for periodontal diseases (p. 18)
- for temporomandibular joint disturbances in dentulous (p.15) or edentulous patients (p. 22)
- for special oral surgical problems
- Place the patient in the apparatus with symmetrical body position
- Have the patient bite into the markings on the bite block, making sure that the mandible is not displaced laterally (danger of asymmetric depiction of the mandible)
- Use the collimator to position the median sagittal plane and the anterior tooth layer
- Position the Frankfurt horizontal provisionally in the collimator

- Check the position of the median sagittal plane and the shoulder position, dorsal view
- Ask the patient to show the teeth, to permit proper final positioning of the occlusal plane, depending upon the indication. Generally speaking, the occlusal plane should be slightly elevated dorsally
- Ask the patient to press the tongue against the palate
- Ask the patient to take shallow slow breaths
- Expose the film

Mistakes in positioning that lead to decreased radiograph quality are frequently caused by the following:
- Asymmetric positioning of the mandible in the bite block
- Asymmetric positioning of the median plane in the cephalostat
- Improper positioning of the occlusal plane; anterior teeth outside the in-focus layer
- Tongue not pressed against the palate
- Failure to remove eyeglasses, contact lenses or jewelry
Increased Radiographic Quality through Positioning According to Indication

The following examples present errors in positioning, as well as tips to improve radiograph quality.

The experienced dentist will be thinking about the indication for the radiograph even as he positions the patient's head in the apparatus. Deviation from the norm will be accompanied by alterations of the projection conditions. The dentist should know to avoid such deviations, and how to put them to use.

21 Positioning in the collimator
If the anterior teeth are located behind the in-focus layer, they will appear wider due to the greater object-film distance. Because they are outside the layer, they will also be blurred in appearance. Compare the diagram (above) and the radiograph (right) in the anterior segment and note the effect of an asymmetric positioning of the median sagittal plane (p. 18).

22 Positioning in the collimator
If the anterior teeth are located in front of the in-focus layer plane, they will appear on the radiograph considerably reduced in size as a result of the smaller object-film distance. Because they lie outside the layer, they will also appear blurred. Compare the diagram (below) and the radiograph (right) in the anterior segment.

- Position the median sagittal plane in the frontal collimator.
- Position the anterior dental segment in the collimator according to the indication.
23 Positioning in the collimator
Using the bite block to position the anterior teeth in the in-focus layer increases the likelihood that the teeth will appear in the radiograph clearly and without distortion. Compare the diagram (above) and the radiograph (left). If the tongue is pressed against the palate during the exposure, the roots of the anterior teeth will show more clearly against the background of this "soft tissue filler."

24 Positioning in the collimator
If it is necessary to take the radiograph with the patient in maximum intercuspsation (e.g., jaw fractures or TMJ problems), the anterior teeth will often appear with a lack of detail because they will be at least partially outside the in-focus layer. Compare the diagram (below) and the radiograph (left). This technique may be used to examine the occlusal relationship via-à-via the condyle position.
25 Improper positioning
Panoramic radiographs taken with the skull tipped too far backward often provide unsatisfactory results. The floor of the nose or the palatal vault shadows the roots of maxillary teeth, and the temporomandibular joints are projected far laterally. In such cases, the following procedure is recommended. After using the collimator to properly position the skull according to the Frankfurt horizontal, check the inclination of the occlusal plane, which may be considerably different from the Frankfurt horizontal. Asking the patient to display the teeth is of help in making this determination. If, when viewed from the side, the occlusal plane deviates considerably from the horizontal and if this inclination is from the dorsal inferior side, the position of the skull should be corrected until the occlusal plane is inclined slightly dorso-laterally and superiorly. The diagrams (right) show the improper positioning from the lateral view and the diagrammatic result (above).

26 Improper positioning
Panoramic radiographs with the skull tipped too far forward often provide unsatisfactory results. The maxillary preglomerare appear superimposed upon each other, and the temporomandibular joints are projected upward. In such cases, the following procedure is recommended. After using the collimator to position the skull according to the Frankfurt horizontal, the inclination of the occlusal plane is checked. Note that the occlusal plane may vary considerably from the Frankfurt horizontal, and that asking the patient to display the teeth will simplify this determination. If the occlusal plane as viewed from the lateral aspect deviates significantly from the horizontal and is inclined significantly dorso-laterally and superiorly, the skull position should be corrected until the occlusal plane is inclined slightly dorso-laterally and superiorly. The diagrams (above) show the improper positioning from the lateral view and the diagrammatic result (right).
Typical Incorrect Positioning

Both of the panoramic radiographs depicted below reveal incorrect positioning of the occlusal plane, which led to unsatisfactory results because of ignorance of the consequences determined by the projection.

Experience has taught that unsatisfactory results may occur despite adherence to the rule that all patients should be positioned according to the Frankfurt horizontal. As is evident from cephalometric radiographs, the angle between the occlusal plane and the Frankfurt horizontal exhibits significant individual variation. The precise position of the dental structures within the facial skeleton makes it necessary in almost every case to position the skull in the cephalostat according to the occlusal plane in order to avoid unsatisfactory radiographs and to obviate the necessity to retake such films. This can be achieved by inspection of the individual relationships before the exposure. For this reason, orthodontists are advised to take the lateral cephalometric radiograph before the panoramic film. If the preparation of the radiographs is delegated to auxiliary personnel, it is a good idea for the dentist to mark the occlusal plane with a skin pencil on the cheek.

27 Incorrect positioning
This panoramic radiograph clearly shows the disadvantage that results from incorrect positioning with the chin elevated. In children, incorrect positioning such as this precludes appropriate depiction of the tooth buds in the maxilla. In cases with TMJ problems, neither the occlusion nor the position of the condyles can be assessed.

28 Incorrect positioning
This panoramic radiograph clearly shows the disadvantages associated with improper positioning with the chin depressed. In children, this positioning may actually be an advantage if the desire is to depict the tooth buds of the maxilla more sharply and not superimposed by the palatal root. On the other hand, this projection is not indicated as a standard projection for periodontal patients because of the superimposition in the premolar region.

The positioning of the occlusal plane should be made according to the indication for the radiograph.
Incorrect Positioning

Unfortunately, despite the cephalostat, no technique exists that can guarantee prevention of a deviation of the median sagittal plane laterally, and thereby an asymmetric portrayal of the structures of the facial skeleton. The positioning of the skull must therefore always also be carefully checked from the dorsal aspect.

The existence of a "technically elicited asymmetry" alters the depiction of normal structures, often to such an extent that they are diagnostically without value for the important lateral comparison.

29. Technically elicited asymmetry of the facial skeleton in two panoramic radiographs

The diagram demonstrates the effect of asymmetric positioning of the median sagittal plane.

Above: This panoramic radiograph clearly demonstrates an asymmetry (the patient also moved during the exposure).

Below: Panoramic radiograph with a relatively minor asymmetry, which nevertheless led to rather severe differences of the depiction of the molars and the bony structures. Compare the shape of the left and right maxillary sinuses and the depiction of the lower concha of the nose.

Positioning of the skull should be palpated dorsally, then checked and corrected.
Positioning in the Mixed Dentition Stage

Depending upon the indication for the radiograph, in patients in the mixed dentition age, either erupted or the not yet erupted tooth buds must lie within the plane of focus of the vertical collimator if they are to appear sharply on the film. If, in addition, impacted or supernumerary teeth (e.g., mesiodens) in the maxilla are to be shown, the patient must be positioned with the occlusal plane inclined steeply dorsally without regard to the resolution of the TMJ. Clinical inspection before closure is absolutely necessary.

30 Improved resolution of the tooth buds in the maxilla of an 8-year-old boy
This film shows the double buds of the maxillary central incisors very well; this situation would not be clearly represented on a single periapical radiograph. The diagram (above) shows how the positioning of the anterior segment of the maxilla (and also of the mandible) can be employed for special indications.

31 Panoramic radiograph of a 7-year-old girl
This film was made after eruption of the incisors, with a somewhat less steep positioning of the skull; this has permitted a good overview because the maxillary premolars are not yet superimposed by the structures of the palatal roof.

If the patient is in the mixed dentition stage, determine the position of the tooth buds in the anterior region before the exposure and, depending upon the indication, position them in the in-focus layer.
Positioning to Visualize Periodontal Destruction

If the patient is properly positioned, panoramic radiography can provide an excellent overview in cases of periodontal disease. With the central ray targeted flat and upward, and concomitantly with the use of the principles of tomography, usually a more realistic representation of the alveolar crest can be achieved than with individual periapical radiographs taken using various projection angles. If any teeth are inadequately portrayed on the panoramic film, targeted periapical radiographs can be used subsequently, thus sparing the patient excessive radiation exposure.

32 Proper depiction of the alveolar crest

The representation will be improved if the occlusal plane is positioned precisely horizontal in the cephalostat. Usually only a few special periapical radiographs (usually in the premolar region of the maxilla) are necessary to complete the survey. In most cases the traditional periapical film series can be avoided in favor of a better overview.

33 Comparison of X-ray targeting for periodontal interpretation using periapical radiographs and the panoramic film

Periapical radiographs (especially with apical projections) provide a distorted picture of the alveolar crest. Buccal portions will be portrayed inferiorly in the maxilla and superiorly in the mandible. Because the axis of the mandibular molars is usually in lingual orientation (see diagram) and that of the maxillary molars is tipped buccally, the panoramic radiograph provides a more realistic view of any bone loss.

Note: As shown in the diagrams, in the mandible the buccal and the lingual portions of the alveolar ridge are shown differently in periapical films (left) and in panoramic radiographs (right). With regard to the actual anatomic situation (long axis of tooth), the panoramic radiograph illustrates the situation more realistically.
Positioning of the Tongue

The quality and therefore the interpretability of panoramic radiographs are significantly influenced by summation effects, especially in the maxillary anterior region as a result of the filter effect of the tongue. If the tongue is maintained in its usual position during exposure, the roots of the maxillary anterior teeth are often invisible in the radiograph due to the lack of filter effect of the tongue. These teeth only become visible if the tongue is pressed against the palate during exposure, thus providing an addition effect. If the filtering effect of the tongue is lacking, subtraction effect occurs.

34 Incorrect tongue position
During exposure, the patient pressed the tip of the tongue against the crowns of the maxillary incisors, thus leaving an empty space below the palatal roof (see diagram, the tongue is depicted in blue). The cavity above the tongue permits a higher irradiation intensity in the region of the maxillary anterior tooth roots, so that these are overexposed and therefore invisible in the final radiograph.

35 Same patient, correct tongue position
During exposure of this film, the patient correctly pressed the tongue against the roof of the mouth. In this position, the tongue acts as a radiation-absorbing filter (in the diagram above, the tongue is depicted in pink). With the tongue in this position, the radiation is weakened before it reaches the roots of the maxillary anterior teeth, and therefore the roots are more clearly visible in the radiograph.

Patients will most likely not understand the mechanism by which panoramic radiographs are made. To avoid incorrect radiographs and the subsequent excessive radiation exposure (re-takes!), it is absolutely necessary to instruct the patient appropriately before exposure. Practicing correct tongue position is time-consuming, but it always leads to significant improvement of radiograph quality, especially in the maxilla.
Depiction of the Alveolar Ridges

The depiction of the alveolar ridges in edentulous patients can sometimes present difficulties because the usually thin alveolar ridge of the maxilla is overexposed; this often occurs if the tongue is not pressed against the roof of the mouth during exposure. In contrast to previous opinions, in edentulous patients it is often effective to leave the patient’s full dentures in place to act as a filter during panoramic radiography. An additional advantage is that with dentures in place it is possible to check the position of the condyles in the fossae.

36 Improved radiographic technique
Improving the quality of panoramic radiographs of edentulous patients requires careful positioning and careful selection of the exposure data. Tongue positioning must be practiced. The diagram (above) shows the improvement of radiographic depiction of the alveolar ridges via use of the filter effect of acrylic prostheses.

37 Patient with complete dentures
If the desire is to gather information about occlusion and the position of the condyles in patients with TMJ problems, it is recommended that dental prostheses (even metal prostheses) be left in situ during exposure, with the patient in centric occlusion. Especially in the maxilla, acrylic prostheses serve as a filter, rendering the alveolar ridge more clearly visible on the radiograph.

The panoramic radiograph taken with the patient in habitual closure is the only film that depicts the occlusion in relation to the position of the condyles. The individual shape and axis position of the joints can render proper depiction more difficult. If the radiograph is taken with the patient biting on a bite block in the anterior edge-to-edge position, it is impossible to observe the position of the condyles in their fossae. The only way to get information about condylar position is with panoramic radiographs taken symmetrically with the patient in habitual occlusion.
"Zonarc" – A Special Instrument for Clinics

Trauma patients are often incapacitated and cannot be appropriately positioned in panoramic radiograph equipment in common dental use. As a consequence, these patients cannot always be examined in the dental office.

For such patients, a special apparatus was developed. It permits zonographic examination of the facial skeleton on a reclining patient. The equipment shown here is the Zonarc M10 (Palomex Co.) which permits not only the preparation of panoramic radiographs but, thanks to its numerous programs, also zonography projections that approximate cylinder-shape layers from various regions of the skull.

This technology demands that the clinician possess profound knowledge of spatial relationships as well as radiographic-anatomic knowledge of the two-dimensional representation of bent layers. A dentist who is experienced in evaluating normal panoramic radiographs will have no difficulty in this regard.

38 Zonarc, patient positioning and movement of the X-ray tube and film cassette
This figure shows the positioning of a patient who, for reasons of photographic clarity, is not draped with a lead apron. This trick photograph nevertheless provides a good idea of the coordinated movement of the X-ray tube and the film cassette around the head of the reclining patient.

39 Use of the Zonarc for simultaneous depiction of both temporomandibular joints with the patient in habitual occlusion
The differing depiction of the condylar heads in this case reveal that the condylar axes are positioned asymmetrically and in differing angles to the median-sagittal plane. The right condyle also exhibits arthrotic alterations.
Special Radiographs Using the Cephalometric Attachment

The technique of cephalometric radiography in the dental practice, formerly used almost exclusively by orthodontists and oral surgeons, has in recent years been simplified and expanded as a result of the extraordinary progress in the area of X-ray technology and film-foil combinations. Today, for example, use of the cephalometric attachment to the panoramic radiographic equipment permits taking the more important skull radiographs with low radiation dosage and with relatively good radiographic quality even in the dental office. This fact will surely enhance dental knowledge.

While modern electronics makes it possible for today's panoramic X-ray equipment to provide an almost unlimited array of projections, these generally do not significantly increase the clinician's information base. On the other hand, X-ray units that can be used with cephalometric attachments are capable of providing skull radiographs in the dental office, and this gives the clinician the distinct benefit of being able to visualize objects in any of the three dimensions. (See p. 109 ff. for the positioning technique for skull radiographs.)

40 Positioning of the patient in the cephalometric attachment of a panoramic radiographic apparatus for a lateral cephalometric film
Note the position of the cervical vertebrae, which avoids superimposition upon the angle of the mandible.

41 Positioning of the patient for a posteroanterior survey radiograph
Note the central ray projection, which causes the petrosal bone to be projected in the inferior portion of the orbit.

42 Waters' projection
The correct positioning with maximum jaw opening shows the proper central ray projection to depict the maxillary sinus without superimposition by the petrosal bone.

43 reverse Towne radiograph
The right photograph shows the correct positioning with maximum jaw opening. The condyles must be visible in the radiograph without any superimposition. The use of a bite block assures proper mouth opening and reduces the possibility of jaw movement during exposure.

In addition to a clear indication, the selected skull radiograph must also be taken according to the standards that govern conventional radiographic technique (see p. 109 ff.).
Radiographic anatomy represents the basis for radiographic interpretation. It follows its own rules and demands understanding and knowledge of how X-rays work, as well as the normal anatomy of the irradiated spaces, depending on the radiographic technique used. Analogous to this essential knowledge, the following basic rules must be obeyed for every type of radiograph:

- The tangential effect of X-rays renders clearly visible in the irradiated space only those hard tissues with either high density or significant thickness; thin lamella which, at the moment of the exposure, are parallel or nearly parallel to the central ray simulate hard tissue of significant thickness and therefore appear in the radiograph as densely opaque. On the other hand, similar structures which, at the moment of exposure, are perpendicular to the central ray or nearly so may, even though they are relatively thick, appear transparent in the radiograph because of the exposure data necessary to penetrate the tissue.

- The summation effect of X-rays may lead to hard and soft tissue structures in the field being exhibited more clearly, or the may disappear entirely depending upon the selection of exposure data. For example, if soft tissues are projected upon one section of the bone, it will appear more dense than adjacent areas because the X-ray beam is already “weakened” when it hits the bone. On the other hand, if an air-containing space is projected onto a section of bone, the situation is one in which the X-ray beam is not weakened before it encounters the bone, penetrates it readily and therefore eliminates the typical radiograph features of bone. The first example is referred to as “addition effect,” and the second example as “subtraction effect.” The situation in such cases has absolutely nothing to do with radiographic signs of “sclerosis” or “resorption.”

Panoramic radiography is not an exception; it depicts in-focus layers of various thickness (but always thicker than 5 mm), and thus may be classified as a type of zonography. In the panoramic radiograph, the picture of the irradiated tissues is determined by the tangential effect and the summation effect; however, in keeping with the principle of tomography, all of the structures within the in-focus layer are shown relatively distinctly and somewhat enlarged, while all structures outside of the layer are depicted as blurred and reduced in size or as blurred, broadened and enlarged superimpositions; such appearance will depend upon whether the superimposed structures are between the in-focus layer and the film or between the in-focus layer and the focal spot.
Survey of the Anatomic Structures Visible in a Panoramic Radiograph

The "trick" photograph of a human skull (Fig. 44) exhibits the surface bony structures, with the exception of the cervical vertebrae and the hyoid bone. Simply viewed, the picture is a composite of a frontal view and two lateral views of the facial skeleton. In an actual radiograph, these surface structures are superimposed by the anatomic spaces and structures lying beneath the surface. In keeping with the principle of zonography, structures such as the cervical vertebrae or the angle of the mandible on the contralateral side are superimposed upon the object in question and therefore compromise its depiction. The sheer number of possibly visible structures is enormous. It is impossible to see all structures in a single picture. This is the reason why in this chapter we will present surveys and sections from various radiographs to give a complete and detailed demonstration of such structures.

44 "Trick" photograph
This picture shows the bony surface structures of the facial skeleton that are captured in a panoramic radiograph. This picture does not, of course, show the hard tissue structures that lie beneath the surface, nor the soft tissues.

45 Diagram of the structures penetrated by the X-ray beam
Numbers 6 and 11 represent areas where numerous anatomic structures are close together; because of space limitation in this diagram, the structures are listed under a single number.

1. Orbit
2. Infratrochlear canal
3. Nasal cavity
4. Nasal septum
5. Inferior nasal concha
6. Nasal foramen, superyeriorly located anterior nasal spine, nasopalatine canal
7. Maxillary sinus
8. Palatal roof and floor of the nose
9. Soft palate
10. Maxillary tuberosity
11. Pterygoid processes (lateral and medial lamina) and the pterygoid process of the pterygoid bone
12. Pterygopalatine fossa
13. Zygomatic bone
14. Zygomaticotemporal suture
15. Zygomatic arch, articular tubercle
16. Coronoid process
17. Condyle
18. External ear with external auditory meatus
19. Cervical vertebrae
20. Temporal crest of the mandible
21. Oblique line
22. Mandibular canal
23. Mental foramen
24. Dorsum of the tongue
25. Compact bone of the inferior border of the mandible
26. Hyoid bone
27. Superimposition of the contralateral jaw
Ventral Portion of the Facial Skeleton

Depending upon the individual development of the facial skeleton and the positioning of the patient in the apparatus, the structures of the orbit and the nasal cavity appear in the picture. But regardless of whether or not these structures are visible or invisible in the radiograph, they do play a role in the overall appearance.

Taking as an example the inferior nasal concha, it is easy to imagine that the panoramic radiograph, as already mentioned, really consists of two broad lateral and one narrow frontal view of the facial skeleton; structures lying further medial and superorally, e.g., the superior nasal concha, are completely invisible. In the inferior portion of the orbit, foreign bodies are sometimes observed, and these appear to lie within the maxillary sinuses; as with the dorsal border of the sinus, the upper portion of the vertically aligned X-ray beam projects such objects obliquely and superiorly.
Ventral Portion of the Facial Skeleton in the Maxilla

Sometimes soft tissue structures appear clearly in the radiograph; this demonstrates that the addition effect must always be considered. On the other hand, the orbits and the maxillary sinuses, together with the nasal cavity and the epiphraynx are easily penetrated by the X-ray beam, and this leads to darkening of the radiograph and a subtraction effect even on the bony background.

Although our primary purpose is not depiction of the soft tissues, an appropriate example will serve to emphasize the result of the addition effect caused by soft tissues. This is emphasized because the shadowing influence of soft tissue may be of significance in diagnosis, especially if the exposure data were at or below the lower limit. On the other hand, the subtraction effects may lead the observer into diagnostic difficulties if the exposure data are at or above the upper limits.

These two examples clearly show the importance of a thoughtfully and carefully performed radiographic technique for the interpretability of radiographs.
Variations in the Maxillary Sinus

Even without technically elicited asymmetries, the individual and varying shapes and sizes of the sinuses demand a high degree of care and interpretation. The example given here presents what appears to be the existence of a cystoid radiolucency in the zygomatic region; however, CT revealed this to be an uncommonly shaped zygomatic recess of the sinus.

The maxillary sinus usually appears in radiographs as a single entity, separated in the region of the second premolar by a septum. The sinus usually consists of more or less pronounced areas that are known as the anterior recess, posterior recess, zygomatic recess or alveolar recess. Sometimes the maxillary sinus appears as a space that is separated by heavy septa; in such cases it may be very difficult to distinguish radiographically between sinus recesses and dentogenic cysts, especially in the presence of nonvital teeth. From the dental point of view, the alveolar recess can usually be distinguished quite well in a panoramic radiograph, but the panoramic film should never be used alone for any examination of the entire sinus.

50. Section from a panoramic radiograph with a cyst-like radiolucency
The radiolucency in the region of the zygomatic recess of the maxilla mimics a pathologic process.

51. CT of the maxillary sinus region, skull reclined
Left: Frontal (coronal) section. Clearly visible is the asymmetry of the maxillary sinus (3) and the distention of the left sinus. Note in the CT the ray-like artifacts that resulted because the patient had metal bridgework. Right: Axial section with the asymmetric sinuses. Note the distended shape of the left sinus (arrow).

1. Orbit
2. Body of the zygomatic bone
3. Maxillary sinus
4. Pterygopalatine fossa
5. Maxillary tuberosity
6. Floor of the nose and palatal root
7. Nasal cavity with conchae and nasal septum
8. Ethmoid sinus
9. Coronoid process
10. Condyle
11. Pterygoid process, lateral and medial laminae
12. Occipital foramen
Retromaxillary Space

The retromaxillary space often presents as a complicated radiographic-anatomic picture because it is often superimposed by the zygoma, the pterygoid process with its two laminae and by the palatal bone. The lateral lamina especially often exhibits numerous variations, exhibiting bony defects and foramina; in the region of the coronoid process, these can produce subtraction effect and simulate the formation of "cystoid" lesions (for example, the pterygospinosum foramen of Civinini or also the crotaphiticobucinator pore, which may occur near the foramen ovale). The "linea innominata" resulting from the temporal aspect of the zygomatic bone represents the posterior portion of the V-shaped shadow which is well known in periapical radiographs of this region, and which "surrounds" the zygomatic recess of the maxillary sinus. It must not be confused with the dorsal border of the sinus, which opens into the anterior portion of the pterygopalatine fossa.

The maxillary tuberosity and the laminae of the pterygoid process are superimposed by the coronoid process, and this renders examination of this region difficult.
External Ear and Temporomandibular Joint Region

Often the auricle and the external acoustic opening are projected onto the articular process in such a way that the shadows caused by the soft tissues create an addition effect while the opening itself elicits a subtraction effect in the condyle; this is a situation that is easy to confuse with "arthritic manifestations."

The panoramic radiograph taken with the patient in maximum intercuspation is the only radiograph that permits an information-rich examination of the occlusion in relation to the position of the condyles. One must also note, however, that the individual shape and axis angle of the joints make evaluation more difficult. On the other hand, if the radiograph is taken with the anterior teeth in edge-to-edge relation, the position of the condyles in the fossae can of course not be evaluated. Radiographs taken symmetrically with the jaws closed can provide the opportunity to examine the condylar positions if the distance from the dorsal edge of the articular process to the ventral border of the condyle can be ascertained. However, definitive statements about condylar position and the shape of the roof of the joint capsule are usually not possible.

54 A particularly clear illustration of a pneumatized articular tubercle of the temporal bone
This and the following figure show the radiographic anatomy in this region. Note that in this and the subsequent figure the teeth were not in contact during the exposure.

55 Subtraction effect
This is a section from a panoramic radiograph that shows the subtraction effect wherein the condyle is superimposed, thus simulating osteolysis. Thorough knowledge of radiographic anatomy and of the subtraction effect will preclude incorrect interpretations.

1 Articular tubercle, pneumatized
2 Condylar process superimposed upon the pterygoid process and portions of the soft palate
3 Condyle
4 Entrance of the auricle with external auditory opening
5 Soft tissues of the auricle
6 Ear tube
7 Styloid process of the temporal bone
8 The medial portion of the glenoid fossa is usually depicted in panoramic radiographs, but is often superimposed by the tympanic crest (Fig. 54)
Palatal Bone in the Shadow of the Coronoid Process

In addition to the lateral lamina of the sphenoid bone, sometimes also the hamulus of the medial lamina of the sphenoid bone and the pyramidal process of the palatal bone are visible. The coronoid process and those portions of the soft palate are superimposed in this region, and therefore an addition effect occurs.

It is imperative to remember that a panoramic radiograph of this region only provides a lateral view, and therefore the correct interpretations are rendered difficult because of the numerous and often surprising summation effects. The solution to this problem must be sought in radiographs that depict this region using a 90° alteration of the projection angle. The lateral view must therefore be supplemented (depending upon the indication) by a frontal or an axial depiction of the region, whether it is by conventional methods or via CT. Even the localization of impacted maxillary third molars should be determined as necessary with this knowledge.

56 Clear illustration of the pyramidal process of the palatal bone, posterior to the maxillary tuberosity.

The adjacent lateral lamina of the pterygoid process is visible. This is a section from a panoramic radiograph.

57 Superimpositions

This is a section from a panoramic radiograph. Despite the superimposition by the muscular attachments on the mandible and the soft palate, the body of the zygoma and the pterygoid process are clearly visible, as is the pyramidal process.

1. Pyramidal process of the palatal bone
2. Lateral lamina of the pterygoid process superimposed over the coronoid process
3. Body of the zygomatic bone
4. Zygomatic arch
5. Maxillary sinus (borders)
6. Pterygopalatine fossa
7. Soft palate
8. Dorsum of the tongue
9. Temporal aspect of the zygomatic bone (incisuraale line)
Tuberosity Region and the Cervical Vertebrae

The major palatine foramen is almost never visible in the panoramic radiograph because of its position perpendicular to the central ray. On the other hand, one often sees the transversal foramen of the second cervical vertebra projected onto the contralateral side, appearing as an enlarged, round radiolucency. Further description of the cervical vertebrae cannot be provided here, but the reader is referred to the special literature of this field. Figure 59 clearly exhibits the subtraction effect caused by the air-containing epipharynx on the depiction of the bony structures of the ascending ramus.

58 Tuberosity region with the dorsal portions of the maxillary sinus and the difficult-to-detect major palatine foramen

The major palatine foramen is vaguely visible superior to the tooth bud of the third molar.

59 Region of the angle of the mandible and the cervical vertebrae

This section from a panoramic radiograph reveals, in addition to the ascending ramus and the angle of the mandible, a portion of the cervical vertebra with the transversal foramen of the second cervical vertebra.

1. Pterygoid process
2. Coronoid process
3. Maxillary sinus (borders)
4. Innominate line (temporal aspect of the zygomatic bone)
5. Major palatine foramen
6. Shadow from the soft tissue of the tongue
7. Shadow from the tissue of the soft palate
8. Air-containing epipharynx
9. Anterior tubercle of the atlas
10. Dens axis
11. Transversal axis foramen
Chin Region

This region is often poorly depicted in panoramic radiographs, either because of the addition effect caused by the cervical vertebrae or the hyoid bone, or because of the subtraction effects if the mental foramen is positioned within the in-focus layer or the intervertebral spaces. Clear and sharp projections of this region, which are possible in young patients because of the low hydroxyapatite content of the vertebral column, nevertheless exhibit radiologically the complex structure of the symphysis following integration of the mental ossicles and the eruption of the permanent anterior teeth. It is therefore not surprising that in this region ossifying fibroma and osteochondroma can be found in addition to the often observed post-traumatic pseudocyst and reparative granuloma.

Also here, it is important to remember that the panoramic radiograph can only provide an anterior summation picture of this region. Individual cases may demand depiction of the third dimension, either via occlusal radiographs or CT.

60 Chin region
This section from a panoramic radiograph depicts particularly well all of the possibilities for the existence of pathologic lesions. The previous symphysis, with the mental ossicles and the endochondral growth from the Meckel's cartilage have left traces of their former existence.

61 Chin region
This section from a panoramic radiograph again shows the chin with the typical triangular shadowing of the protuberance and the hyoid bone. The mental foramen can be seen within the poorly trabeculated bony structure of the body of the mandible.

1 Mental protuberance
2 Mental foramen
3 Shadow of the hyoid bone
4 Compact bone of the mandible
5 Mental tubercle
6 Digastric (lingual) foramen
7 Mental foramen
8 Internal mental spine
Figure 62 displays particularly well how the mental fovea may appear as a poorly demarcated osteolytic area if it is serendipitously located directly in the in-focus layer. Class II patients and those with pronounced fovea often exhibit this phenomenon. It is as well to mention that cystoid alterations in this region (p. 34) always depict a clear and typical margin contour if inflammation is not present. Malignant changes are extremely rare, with exception of the osteoclastoma.

Additional radiolucencies in this region may be caused by the intervertebral spaces between the first and the fourth cervical vertebrae. Depending upon the position of the skull in the cephalostat, these may present as narrow, roof-like radiolucencies, and may also be projected onto the anterior region of the maxilla (Figs. 35, 37, 66 and 67).

62. Clear depiction of a radiolucency caused by the upper portion of the mental fovea
Section from a panoramic radiograph. The buccolingual dimension of the bone is especially narrow in this area, and therefore often exhibits a well-demarcated radiolucency that is often difficult to distinguish from a pathologic lesion such as the traumatic pseudo-cyst. Note the reactive sclerosis in the periapical region. This followed a disturbed eruption of vital tooth 44.

63. Clear depiction of the portion of the mental fovea inferior to the mental tubercle
Section from a panoramic radiograph. The mental fovea appears very frequently as a confusing radiolucency if the fovea itself is positioned directly in the in-focus layer. Note the small enostosis apical to tooth 34.

1. Mental protuberance
2. Mental tubercle
3. Mental fovea (upper portion)
4. Lower portions of the mental fossa as it encompasses the protuberance.
5. Mandibular canal
6. Mental foramen
7. Compact bone of the mandibular border
Chin Region and the Body of the Mandible

The section from a panoramic radiograph also exhibits a view of the chin region with an additional variant in terms of radiolucency. If the submaxillary fovea is especially pronounced, a significantly radiolucent and poorly trabeculated region may be observed beneath the clearly demarcated mylohyoid line. It is not infrequently diagnosed as a cystic alteration when observed in periapical films because of the lack of a broader view. The mandibular canal is often invisible if the body of the mandible is excessively radiolucent, and often only the floor of the canal can be identified. On the other hand, the mylohyoid line may be superimposed upon the course of the mandibular canal and render its identification more difficult.

64. Digastic fovea
This section from a panoramic radiograph reveals the pronounced depressions that represent the attachments of the lingual digastic muscle, creating bilaterally the digastic foveas. Note also the small osteoma left of this midline on the inferior border of the mandible.

65. Mylohyoid line
This panoramic radiograph shows a clearly formed mylohyoid line on both left and right sides of the mandible. This structure is the attachment point for the mylohyoid musculature and is immediately coronal to the submaxillary fovea, which appears as a radiolucency on both sides.

1. Compact bone of the mandible
2. Mental protuberance
3. Digastic fovea
4. Mental foramen
5. Mental foramen
6. Mylohyoid line
7. Submaxillary fovea
8. Hyoid bone
9. Base of the tongue
10. External auditory opening and soft tissues
11. Small osteoma
12. Radiolucency created by the lips
Mandibular Canal, Mandibular Ramus and the Cervical Vertebrae

The mandibular foramen is usually difficult to discern on a panoramic radiograph because of the superimposition of the contralateral side of the jaw. Exceptions do occur, as shown in Figure 66, where the mandibular foramen is more inferior than normal and therefore readily visible. The course of the mandibular canal is usually readily visible in younger individuals to the second molar. From there to the mental foramen it is seldom readily visible because of the porosity of the canal walls, the superimposition of the highly radiolucent submaxillary fora and the lack of trabeculation.

If the canal is visible, it appears as a fine radiopaque line; the mental foramen, located buccally, is superimposed by the bony lingual structures and is seldom clearly visible, but topographically more adequate than in periapical radiographs.

Examination of the mandible in panoramic radiographs is also complicated due to the addition effects by superimposition of the mandibular ramus onto the angle of the mandible on the opposite side; subtraction effects also may interfere due to the air-containing epipharynx, especially if the patient inhales deeply.

66 Mandibular foramen
This panoramic radiograph exhibits bilaterally well-formed mandibular foramina that are located more inferior than normal. This could be mistaken for osteoma if the radiographic resolution of the ascending rami were not sharp, because the depression is covered only by a lateral bony plate without spongy bone. Note also the depiction and superimposition of the highly hydroxyapatite-containing cervical vertebrae, a phenomenon of age.

67 Course of the ventral segment of the mandibular canal in an edentulous patient
The atrophy of the alveolar process of the mandible has created a situation in which the mental foramen is at the crest of the ridge. This film also shows the subtraction effect caused by the air-containing epipharynx.

1 Mandibular foramen
2 Coronoid process
3 Zygomatic arch
4 Frontal view of cervical vertebrae
5 Subtraction effect caused by air-containing epipharynx
6 Base and dorsum of the tongue
7 Mental foramen
8 Mandibular canal
Mandibular Canal and Retromolar Structures

The structures of the body of the mandible and the retromolar region are usually targeted too steeply caudally when dental X-ray equipment is used. In addition, the long axes of the molars are inclined lingually. The panoramic radiograph provides a less distorted view of these structures because the central ray is targeted lingually and slightly from below in this region. In addition, if the mandibular canal and the mental foramen are visible despite the summation effect, the distance from these structures to the crest of the ridge is more faithfully reproduced. A lateral tomograph can provide a better projection (as might be needed by an implantologist), but only if the skull is properly positioned with the mandibular canal parallel to the film. In addition, the use of low energy exposure is recommended because this will help to eliminate the summation effect on regular films and tomographs.

When making interpretations concerning retromolar structures, note that the lingual aspect of the retromolar area is projected upward.

In this section from a panoramic radiograph (left) the mental foramen is depicted in its normal location. In the periapical film (right), however, the mental foramen appears more coronal than normal. The external oblique line together with the temporal crest comprise the retromolar trigone.

In this section from a panoramic radiograph and that above (Fig. 68) demonstrate that the mandibular canal often cannot be discerned clearly along its entire length.

1. External oblique line (continuation of the anterior margin of the ascending ramus)
2. Temporal crest with retromolar trigone
3. Mental foramen
4. Mandibular canal
5. Compact bone of the mandible
Hyoid Bone and Cervical Region

If the hyoid bone moves during the exposure because the patient swallows, it usually appears very blurred on the radiograph and is projected up onto the body of the mandible as an addition effect. This addition effect occurs particularly frequently in prognathic patients with a flat mandibular angle, or if the mandible is positioned too steeply toward the cervical vertebrae. The artefact may give the appearance of a large stone in the duct of the submandibular gland. It is for this reason that the practitioner must recognize the importance of proper positioning of patient, skull and mandible before the exposure.

Sometimes even the epiglottis will be visible as an addition effect on the major horn of the hyoid bone. Using the conventional lateral jaw projection technique, with the central ray somewhat lower and the exposure made with lower energy it is possible to provide a better depiction of the hyoid bone (p. 40). Post-traumatic degenerative alterations of the hyoid bone are difficult to ascertain. Sometimes this may be accomplished using axial or lateral projections in film tomography or CT.

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70. Addition effect in the body of the mandible
In this section from a panoramic radiograph, note the addition effect in the body of the mandible that was caused by superimposition with the hyoid bone. In this picture the mandible appears steeply oblique and near to the cervical vertebrae. This type of addition effect is difficult to avoid in prognathic patients with flat mandibular angles.

71. Region of the hyoid bone with superimposition by the epiglottis
The hyoid bone appears without distortion and in its normal position because the mandible was positioned forward and far removed from the cervical vertebrae. Note also the typical thin compact bone at the angle of the mandible.

1. Body of the hyoid bone
2. Major horn of the hyoid bone (the minor horn is almost never visible)
3. Epiglottis
4. Angle of the mandible
5. Mandibular canal
6. Cervical vertebrae
7. Compact bone of the mandible
8. Mental foramen
Hyoid Bone and Subtraction Effect from the Base of the Skull

Very occasionally, one has the opportunity to see in a panoramic radiograph the minor horn of the hyoid bone, which may be connected joint-like with the body of the hyoid bone. This secures the flexible attachment of the hyoid bone to the styloid process via the stylohyoid ligament.

Equally rare is the observation of a summation effect from the base of the skull, which may become visible as more or less sharply demarcated radiolucencies in the region of the semilunar suture. Such cases represent normal anatomic variation and include for example the pterygospinous foramen of Civinini or the crotaphiticoebuccinator pore (p. 30). Today such variations can be appropriately clarified using an axial CT.

72 Rare illustration of the minor horn of the hyoid bone
The minor horn of the hyoid bone appears to connect via a "joint" to the body of the hyoid bone. This represents a portion of the connection of the hyoid bone to the base of the skull. Injuries to the ligament apparatus, which sometimes lead to more or less complete ossification of the stylohyoid chain, may elicit occlusal disturbances that are difficult to diagnose clinically.

73 Enlarged radiolucent area above the semilunar suture
This is a section from a panoramic radiograph. The radiolucency appears as a typical subtraction effect extending from the base of the skull. Other radiolucencies in the ascending ramus of the mandible may be caused by the rare pterygospinous foramen of Civinini or the crotaphiticoebuccinator pore.

Figure 72:
1. Body of the hyoid bone
2. Major horn
3. Minor horn
4. Angle of the mandible
5. Mandibular canal

Figure 73:
1. Orbit (border)
2. Maxillary sinus (border)
3. Pterygopalatine fossa
4. Zygomatic bone
5. Innominate line
6. Zygomatic arch
7. Condyle
8. Internal auditory opening
9. External auditory meatus
10. Radiolucency caused by the base of the skull
Angle of the Mandible and the Styloid Process

A tubercle sometimes forms either laterally from the attachment of the masseter muscle or linguually from the attachment of the medial pterygoid muscle, which anatomists term the angular process of the mandible. However, peripheral osteoma may also occur at precisely this location.

The stylohyoid ligament may partially or completely ossify, with formation of the so-called stylohyoid chain. Often several joint-like connections can be discerned. Today, seemingly minor automobile accidents involving whiplash injuries often lead to long-term undiagnosed yet persistent damage to the stylohyoid ligament and the ossified portions of the stylohyoid chain.

74. Angular process of the mandible
In this section from a panoramic radiograph, the so-called angular process of the mandible is clearly depicted. This structure probably derives laterally from the attachment of the masseter muscle or lingually from the attachment of the medial pterygoid muscle.

75. Long styloid process
The styloid process has formed an almost complete stylohyoid chain to the minor horn of the hyoid bone. Note the radiolucencies caused by the air-containing spaces in this region.

1. Dorsum of the tongue
2. Floor of the nose with roof of the palate and the soft palate
3. Both maxillary sinuses superimposed upon the nasal cavity create a dramatic radiolucency
4. Air-containing epipharynx and the region of the posterior nasal aperture
5. Styloid process with joint-like connection
6. Radiopacity caused by the distal side of the mandible
7. Mylohyoid line
8. Maxillary sinus (border)
9. Angular process of the mandible
10. Condyle (medial)
11. Condyle (lateral)
Examination of Children and Adolescents Using the Panoramic Radiograph

The prevalence of dental diseases has decreased in recent years because of the effect of dental preventive measures. Bite-wing radiographs are indicated for detection of coronal caries but they are not suitable for the examination of the jaws. The method of choice today to examine the jaws for anomalies and pathologic processes is panoramic radiography, and should be performed at a minimum during the 9th, 15th and the 20th years of life.

Summarized simply, the following developmental anomalies can be expected in children and adolescents:
- Disturbance of the normal developmental morphogenetic processes of the bony structures of the jaw, including the temporomandibular joints in early childhood as well as during the course of the first and second decades of life, with formation of typical tumors and tumor-like lesions.

76 Panoramic radiograph of a 3½-year-old girl with deciduous dentition
While the formation of the crowns of the first permanent molars is complete, formation of the cusps of the second molars has only begun.

77 Panoramic radiograph of a 5-year-old boy with deciduous dentition
While root formation of the first permanent molars, the incisors and the canines is already in process, the formation of the crowns of the second permanent molars is not yet complete. Clearly visible are the maxillary sinuses.

78 Panoramic radiograph of a 6-year-old girl in early mixed dentition stage
The first permanent molars and partially also the incisors have erupted; root formation is almost complete. The articular process has obviously begun to elongate.
Improper development of the dental structures during the growth-intensive mixed dentition stage, with congenitally missing or supernumerary teeth as well as formation of typical odontogenic cysts and tumors, especially in the second decade of life.

- Dysgnathia
- Systemic diseases

Specific dental diseases and inflammatory processes in the jaws may also play additional roles.

The selection of panoramic radiographs presented here derived from a 3½-year-old child to an 18-year-old adolescent. These films depict the development of the teeth and the maxillofacial structures in the facial skeleton of young persons. Of special note is the development of the maxillary sinus in the skull of early childhood, as well as the development of the ascending rami of the mandible and the formation of the temporomandibular joints.

79. Panoramic radiograph of an 8-year-old girl in the mixed dentition stage
The apical portions of the roots of the first permanent molars are forming. Root formation of the other permanent teeth is progressing.

80. Panoramic radiograph of a 10-year-old girl in the mixed dentition stage
The formation of the apical portions of the roots of the first permanent molars is complete. The crowns of the extremely variable third molars are visible.

81. Panoramic radiograph of a 12-year-old girl in the mixed dentition stage
The deciduous canines and the deciduous molars are being resorbed by the erupting permanent teeth. The second permanent molars are erupting. The condyles no longer exhibit the round shape characteristic of children.
82  Panoramic radiograph of a 14-year-old male with permanent dentition
The roots of the permanent teeth and most of the apical foramina have formed.

83  Panoramic radiograph of a 16-year-old female with permanent dentition
The root canals of the most recently erupted teeth are becoming narrower. The extremely variable third molars appear in various stages of development.

84  Panoramic radiograph of an 18-year-old male with fully developed permanent dentition
Diagram of Formation and Eruption of the Deciduous Teeth

The eruption of the deciduous teeth occurs according to the following time sequence:

<table>
<thead>
<tr>
<th>Tooth Type</th>
<th>Time Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central incisors</td>
<td>6–8 months</td>
</tr>
<tr>
<td>Lateral incisors</td>
<td>8–12 months</td>
</tr>
<tr>
<td>Canines</td>
<td>15–20 months</td>
</tr>
<tr>
<td>First deciduous molar</td>
<td>12–16 months</td>
</tr>
<tr>
<td>Second deciduous molar</td>
<td>20–40 months</td>
</tr>
</tbody>
</table>

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*Formation and eruption of the deciduous teeth of the maxilla*

The eruption times of the deciduous teeth in the mandible are very close to their maxillary analogues.
Diagram of the Formation and Eruption of the Permanent Teeth

The eruption of the permanent teeth usually occurs according to the following time sequence:

<table>
<thead>
<tr>
<th>Type</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central incisors</td>
<td>6 – 8 years</td>
</tr>
<tr>
<td>Lateral incisors</td>
<td>6 – 8 years</td>
</tr>
<tr>
<td>Canines</td>
<td>10 – 14 years</td>
</tr>
<tr>
<td>First premolars</td>
<td>9 – 12 years</td>
</tr>
<tr>
<td>Second premolars</td>
<td>10 – 13 years</td>
</tr>
<tr>
<td>First permanent molars</td>
<td>6 – 7 years</td>
</tr>
<tr>
<td>Second permanent molars</td>
<td>10 – 13 years</td>
</tr>
<tr>
<td>Third permanent molars</td>
<td>16 – 30 years</td>
</tr>
</tbody>
</table>

86 Formation and eruption of the permanent teeth of the maxilla
The eruption times of the mandibular permanent teeth are similar to their maxillary analogues.

6 years

9 years

10 years

11 years

13 years
Tips for Preparation of Perfect Panoramic Radiographs

Before Positioning the Patient in the Apparatus

- Take the time to explain the apparatus and the film cassette rotation to the patient
- Set the appropriate exposure data
- Have the patient remove all jewelry from ears, hair and neck
- Demonstrate the bite holder for the patient; he or she should practice biting in centric relation

- Have the patient practice proper tongue position
- Depending upon the indication, either remove the patient's prosthesis or leave them in situ
- Apply the protective lead apron to the patient
- Utilize appropriate barrier techniques

243 Improper positioning of the patient: Head tipped too far forward
Note the superimposition effects in the premolar regions of the maxilla. The temporomandibular joints are projected completely out of the film.

244 Improper positioning: Head tipped too far back
Note the superimposition on the maxillary alveolar process by structures of the floor of the nose and the palatal root. The temporomandibular joints are projected far laterally.

245 Old equipment
When using older equipment, the film cassette must be placed precisely in the initial position before positioning the patient in the apparatus to preclude loss of important radiographic information. Failure to do so will result in the necessity to retake the radiograph, and therefore, additional radiation exposure for the patient.
With the Patient in the Apparatus

The technician should position and check for:
- Body position
- Head position
- Positioning of the image layer using the collimator
- Occlusal plane (depending upon indication)
- Position of the protective lead apron (from behind)

Setting of the median sagittal plane using the collimator
- Setting of the median sagittal plane (from behind)
- Final check
- Ask patient to continue shallow breathing
- Exposure

246 Movement of the head during the exposure

Apparent deformation of both maxilla and mandible at the same location because the narrow sit diaphragm creates vertical tracks in the same direction of movement.

247 Movement of the mandible during the exposure

This movement has created typical deviations from the norm (compare with the body of the mandible, right), limited to the mandible.

248 Movement of the mandible during the exposure

This postoperative follow-up radiograph reveals a step in the thinned cortical bone on the left side that suggests a spontaneous fracture.
Tips for Preparation of Perfect Radiographs

Before Exposing the Film

- Set the exposure data appropriately
- Explain the procedure to the patient
- Ask the patient to remove eyeglasses, jewelry and prostheses
- Wash hands and put on rubber gloves in view of the patient

- Take time to position the film, noting any sensitivity of the patient
- Apply topical anesthetic as required
- Ask the patient to breathe through the nose (shallow breathing)

249  Foreign body
The earring that was left in place on the right earlobe during radiographic exposure created a blurred, enlarged ring of radiopacity at the left angle of the mandible. With the typical X-ray projection, this artifact was projected superiorly.

250  Foreign body
The metal jewelry in the right earlobe created in the tuberosity region of the left maxilla a blurred, enlarged and somewhat more superiorly located radiopacity. Incorrect interpretation of such a radiographic appearance could result.

251  Foreign body
The protective lead apron was not carefully positioned and created a dense, typical radiopacity. This usually is observed in the apical region of the mandibular anterior teeth.
Immediately Before Exposure

- Position the patient’s head appropriately
- Insert and position the film packet in the available space and without bending
- Utilize cotton rolls or, better, a film holder
- After film placement and immediately before exposure, ask the patient to close slightly—the patient will relax.

- Recheck head position
- Target the X-ray tube onto the object, also when using a film holder
- Exposure

252 Napkin chain
The chain holding the patient’s napkin may appear on the film and make interpretation difficult. It must therefore be removed before exposing the film. Similarly, if the patient is wearing clothing with a zipper at the neck, it should be opened before the exposure.

253 Carelessly placed protective apron
In elderly patients with kyphosis, this often leads to interference with the film cassette movement, which causes jerky movement of the X-ray source. This results in a striped exposure of the film (left).

254 The patient’s breathing should be shallow during the exposure
In this picture, one sees the impressive subtraction effect that results from air, which serves as a negative contrast medium on the ascending mandibular rami if the patient holds his or her breath and presses against the closed palatal vault.