5. ORAL RADIOLOGY

Bernard Friedland, B.Ch.D., M.Sc., J.D.

RADIATION PHYSICS AND BIOLOGY

1. How are x-rays produced?

X-rays are produced by "boiling off" electrons from a filament (the cathode) and accelerating the el to the target at the anode. The accelerated x-rays are decelerated by the target material, resulting in bremsstrahlung. Characteristic x-rays are produced when the incoming electrons knock out an inner K- or L-shell electron in the target and an electron from the L or M shell falls in to fill the void.

2. At the energies typically used in dental radiography, what interactions do the x-rays undergo with tissues?

X-rays undergo three interactions with tissue: elastic scatter, Compton scatter (also known as inelastic or incoherent scatter), and photoelectric absorption. Pair production occurs at much higher energy values (1.02 megaelectron volts [than are used in dentistry.

3. Which of the interactions is primarily responsible for patient dose?

In the photoelectric process the incoming x-ray transfers all of its energy to the tissue. Photoelectric absorption, therefore, contributes the most to patient dose.

4. Why are filters used?

Filters are used to remove the low-energy x-rays, which are primarily responsible for photoelectric interactions and patient dose. Removing these x-rays inéreases the average energy of the beam and reduces the likelihood of photoelectric interactions, thereby reducing patient dose.

5. Why are intensifying screens used in extraoral radiography? How do they work?

Intensifying screens are used to reduce patient dose. They do so by converting x-rays to light. Since one x-ray gives rise to many light photons, the number of x-rays required to produce the same density on the film is markedly reduced.

6. What radiosensitive organs are in the field of typical dental x-ray examinations?

The thyroid is an extremely radiosensitive organ, along with lymphoid tissue and bone marrow in the exposed areas.

7. What evidence suggests a risk of carcinogenesis from exposures to low levels of ionizing radiation such as those in dentistry?

No single study proves the association between carcinogenesis and exposure to x-rays at the low levels used in dentistry. Many studies that follow patients exposed to higher levels, however, provide evidence of a link. Populations that have been studied include atomic bomb survivors in Nagasaki and Hisoshima, radium watch-dial painters, patients exposed to multiple fluoroscopies for tuberculosis, and others.

8. What units are used to describe radiation exposure and dose? WThat do they measure?

I. The roentgen (R) is the basic unit of radiation exposure for x- and gamma radiation. It is defined in terms of the number of ionizations produced in air.

2. The rad (roentgen absorbed dose) is a measure of the amount of energy absorbed by an organ or tissue. Different organs or tissues absorb a different amount of energy when exposed to the same amount of radiation or roentgens.

3. The rem (roentgen equivalent man or mammal) is a measure of the degree of damage caused to different organs or tissues. Different organs or tissues show differing amounts of damage even when they have absorbed the same amounts of rads.

The International System of Units (SIs) are the coulomb/kilogram, the Gray, and the Sievert for the roentgen, rad, and rem, respectively.

9. What are the effects of ionizing radiation on the cell?

Radiation damage to the cell is divided into direct and indirect effects. A **direct** effect takes place when the radiation interacts directly with a biologic molecule to produce damage:

1. $RH \longrightarrow RH^+ + e^-$

2. $RH \longrightarrow R^+ + H^+$

An **indirect** effect occurs when the radiation interacts with a nonbiologic molecule, which then interacts with a biologic molecule and results in cell damage:

1. $H_2O \longrightarrow H_2O^+ + e^-$

2. $H_2O^+ \longrightarrow H^+ + OH^o$

3. $RH + OH^o \longrightarrow R + H_2O$

10. What is the difference between density and contrast?

Density refers to the overall degree of blackening of a film. Contrast refers to the differences in densities between adjacent areas of the film.

11. Which technique factors control film density?

The longer a film is exposed, the darker it will be; hence, time of exposure controls density. The milliampere (mA) determines how hot the filament gets and how many electrons are boiled off. The greater the filament current, the hotter the filament and the more electrons are boiled off to reach the anode and to produce x-rays; hence mA also controls density. As a result of the kilovolt peak (kVp), which is the potential voltage difference between the cathode (filament) and anode, electrons that are boiled off are accelerated to the anode. The greater the potential difference between the cathode and anode, the greater the acceleration of the electrons toward the anode. Electrons that hit the anode at greater speed result in x-rays with higher energies. X-rays with higher energies are more likely to reach the film and blacken it. Thus, kVp also controls film density. The distance from the source to the film also has a great effect on film density (see question 17).

12. Which technique factors control film contrast? How do they affect contrast?

Contrast is controlled by the kVp only. The higher the kVp, the lower the contrast, and vice versa. Time, mA, and distance affect only density and not contrast.

13. Assume that you manually develop your x-ray films and that you do not know the de veloping time. What is the best way to ensure an acceptable film?

If you do not know the developing time, the best option is to develop by sight. Remove the film from the developer from time to time and visually determine whether you have sufficient density (assuming that the exposure was made correctly). Be careful not to expose the film to daylight.

14. Assuming that you have manually developed the film, how long should you fix it?

A general rule of thumb is to fix the film for at least twice the developing time. Thus, you should know how long you took to develop the film and then fix it for at least double that time.

15. How is the latent image on an x-ray film converted into a visible image?

When a film is developed, the exposed silver halide crystals are converted to metallic silver, which blackens film and thus makes the image visible.

16. How do you trouble-shoot a dental radiograph that is too dark or too light?

Changes in radiographic quality most commonly result from errors in processing and less commonly, but not rarely, from errors in technique factors. Check the exposure factors (kVp, mAs) to ensure that they were appropriate for the patient. Check the chemicals to ensure that they are at the correct temperature, that they have been stirred, and that they are fresh. If all of these factors are satisfactory, evaluation of the x-ray unit or film may be necessary. A problem with either is rare.

17. What is the inverse square law?

The intensity or exposure rate of radiation at a given distance from the source is inversely proportional to the square of the distance. If we double the distance from the source, for example, the intensity of the radiation is reduced fourfold.

18. How do we control scatter radiation?

In intraoral radiography, we do not control scattered x-rays that result from the interaction of x-rays with the patient. We do try, however, to minimize the scatter by use of a lead-lined long cone. In extraoral radiography, such as cephalometric radiography, scattered radiation is controlled by the use of a grid that is situated between the patient and the x-ray film.

19. What is meant by film speed? How is film speed expressed?

Film speed refers to the amount of radiation required to produce a particular density. Thus, the faster a film, the less radiation is needed to produce the same density than for a slower film. The speed of a film is expressed as the reciprocal value of the number of roentgens required to produce a density of one. Thus, if 5 roentgens are required to produce a density of one, the film speed is 0.20. If 8 roentgens are required to produce a density of one, the film speed is 0.125.

20. What is meant by the terms sensitivity, specificity, and predictive value when applied to the efficacy of radiographic examinations?

Sensitivity refers to the ability of a test, in this case a radiograph, to detect disease in patients who have disease. Thus, sensitivity is a measure of the frequency of positive (true-positive rate) and negative (false-negative rate) test results in patients with disease. Specificity refers to the ability of a test to screen out patients who do not in fact have the disease. Thus, specificity is a measure of the frequency of negative (true-negative rate) and positive (false-positive) test results in patients without disease. The predictive value of a radiograph is the probability that a patient with a positive test result actually has the disease (positive predictive value) or the probability that a patient with a negative test result actually does not have the disease (negative predictive value).

21. What is the basic technology behind magnetic resonance imaging (MRI)?

Atoms in the body act like bar magnets. In the MRI procedure, the area to be examined is subjected to an external magnetic field. The atoms line up with the magnetic field so that their long axes point in the same direction, just as one finds when bar magnets are subjected to a magnetic field. Once the atoms are so aligned, they are also subjected to a radio wave. The atoms absorb some of the radio wave's energy and lean over. When the radio wave is turned off, the atoms "relax" and emit the energy that they absorbed. This energy can be picked up by appropriate receivers and converted into a picture.

22. What is the trend with respect to use of a lead apron and thyroid collar to protect a pa tient from radiation?

Although as yet there is no consensus on the issue, there is an increasing tendency **not** to use lead aprons and thyroid collars in dental radiology. The feeling is that with modern machines, well-collimated beams, and fast films, the use of a lead apron offers no additional protection because virtually all of the patient dose is a result of internal scatter radiation. An exception, even among those who have discontinued use of the lead apron and thyroid collar, is occlusal films in younger patients. In occlusal radiography, the sensitive thyroid gland of younger patients is frequently in the path of the primary beam.

RADIOGRAPHIC TECHNIQUES

23. What are the advantages of using the paralleling technique?

In the paralleling technique the film is placed parallel to the object or tooth, and the central ray is directed perpendicular to both the object and the film. The result is an image with relatively minimal distortion. In the bisecting angle technique, by contrast, the film is not parallel to the tooth, and the central beam is directed at 90° to an imaginary line bisecting the angle formed by the long axes of the tooth and film. The result is a more distorted image.

24. What are the advantages of the long-cone technique?

The long-cone technique has two primary benefits. The long cone reduces patient dose by reducing the field size. It also increases the target-film distance, thereby reducing magnification.

25. Why is it important to obtain right-angle views of any radiographic abnormality?

Radiographs are two-dimensional representations of three-dimensional objects. To obtain a three-dimensional view with film, one needs to obtain views at right angles to each other. For example, a periapical film suggesting a cyst of the mandible should be supplemented with an occlusal view and a posteroanterior (PA) view of the mandible.

26. If you intend to remove a tooth surgically—for example, an impacted second bicuspid— how can you determine whether the impacted tooth lies buccal or lingual to the erupted teeth?

A periapical view shows only the mesiodistal location of a tooth relative to other teeth. To determine its buccolingual relation, you need a view at right angles to the periapical view. An occlusal view is generally the easiest view to take and is the only intraoral view that you can take at 90° to the periapical view. In areas where it may not be possible to get an occlusal view, such as the third molar region, a PA mandibular film may be the best solution. This, of course, is an extraoral view. You could also determine the impacted tooth's buccolingual relation by exposing a second periapical view with the tube positioned either more mesially or distally compared with the first periapical exposure. By applying the buccal object rule, you can then determine the impacted tooth's buccolingual relation to the erupted teeth.

27. What are the indications for an occlusal film?

- To determine the buccolingual position of an impacted tooth
- To demonstrate the buccal and lingual cortices, particularly in the mandible
- To visualize the intermaxillary suture
- To demonstrate arch form
- To replace periapical films in young children

An occlusal film also may be used when one wishes to visualize on one film a lesion that is too large to fit on a single periapical film.

28. What operator error results in a foreshortened image?

Foreshortening results when the vertical angulation of the tube is too great; that is, the tube is angled too steeply. Elongation, by contrast, results from a vertical angle that is too shallow. A good way to remember cause and effect is to think of the sun and your shadow. Your shadow is shortest at noon when the sun is highest in the sky (a steep vertical angle) and longest in the late afternoon when the sun is low in the sky (a shallow vertical angle).

29. Is it preferable to err on the side of foreshortening or elongation? Why?

If one is going to err, it is best to foreshorten. Think again of the sun and shadows. The short shadows produced by the high-noon sun have crisp, well-delineated margins, whereas the long shadows produced by the low late-afternoon sun disappear into the distance with ill-defined mar gins. It is better to have a foreshortened image that is crisp rather than an elongated image that is difficult to read. This is particularly true when one is examining the apical area.

30. Which radiographic view is considered the primary view for evaluating the alveolar bone for periodontal disease? What are the radiographic manifestations of periodontal disease?

The bitewing view is the primary view for evaluating radiographic changes consistent with periodontal disease, which include loss of crestal cortication, changes in the contour of the interdental bone, horizontal and angular bone loss, and furcation involvement. The bitewing film is superior to a periapical film because distortion, including elongation or foreshortening, is slight. The reason is that the vertical angle is small (approximately 5°), and the central ray is directed at right angles to the film.

31. Is there a generally accepted protocol for the frequency of radiographic evaluation in adult dental patients?

Yes. The United States Food and Drug Administration, in cooperation with the American Dental Association and other major organizations, has developed and disseminated protocols for exposing dental patients to x-ray examinations. These protocols require a history and clinical examination before prescribing an individualized radiographic examination.

32. How should radiographic protocols be altered for pregnant dental patients?

With the use of standard radiation protection, there should be no additional risk to the fetus from x-ray exposures commonly used in dentistry. However, because of the concerns many women have during pregnancy, it is advisable to limit x-ray exposures to the necessary minimum.

33. In a patient who has trismus and whose teeth you wish to examine, what alternatives to the standard bitewing and periapical views may be used?

Intraorally, buccal bitewings can be used. For buccal bitewings, insert a standard no. 2 film into the buccal vestibule with the tube side facing the teeth. Direct the cone from the opposite side, and increase the time exposure by two steps. If the patient can open even slightly, an occlusal view also can be done. The lateral occiusal film can give an excellent view of the teeth, including the periapical regions. Extraorally, a lateral oblique film can be obtained. Although it does not give as detailed information as an occiusal film, the lateral oblique also depicts the teeth and surrounding periapical regions. A panoramic film has less resolution than the occlusal film and possibly even less than the lateral oblique (depending on the screen-film combination). Thus it provides less detail than either of the two.

34. What are the differences between standard intraoral radiography (bitewings and periapicals) and panoramic radiography?

1. Bitewing and periapical techniques use direct-exposure film while the panoramic technique uses intensifying screens.

2. The panoramic view uses a tube movement that results in loss of detail and resolution.

35. What imaging techniques are available to evaluate the soft tissue components of the temporomandibular joints (TMJs)?

Three imaging procedures are available for evaluation of the soft tissue components of the TMJs: arthrography, computed tomography (CT), and MRI.

MRI studies are becoming more widely used because they image soft tissue well, do not employ ionizing radiation, and are noninvasive. Arthrography is the most invasive and involves the introduction of contrast into one or both joint spaces.

36. Name the paranasal sinuses and the radiographic views commonly used to evaluate the sinuses.

The paranasal sinuses are the frontal sinuses, the maxillary sinuses, the spheroid sinuses, and the ethmoid sinuses. The views used to evaluate them are the Waters view (maxillary sinus), the Caldwell view (maxillary and frontal sinus), the lateral view (maxillary and frontal sinus), and the submentovertex view (spheroid and ethmoid sinus). A panoramic film may be used as an adjunct to these views. The panoramic film shows the maxillary sinus.

The view of choice depends on precisely what is under examination. For example, the submentovertex view permits excellent visualization of the lateral wall of the maxillary sinus, whereas the Waters view depicts the medical, lateral, and inferior borders of the maxillary sinus.

37. What plain film views may be used to visualize the TMJ?

The transpharyngeal or Parma view provides an image mainly of the lateral aspect of the condyle. The lateral transcranial view also provides an image mainly of the lateral aspect of the condyle. Its main purpose is to depict the condyle-glenoid fossa relationship. The Zimmer or trans- or periorbital view provides a mediolateral image of the condyle as well as the condylar neck. A reverse Towne view is useful for visualizing the condylar neck. Keep in mind that tomography provides better visualization of the TMJ than plain film views. The above views, however, are relatively easy to take.

38. What are the indications for a panoramic film?

There is no specific indication for the panoramic film. Virtually any structure that is portrayed on a panoramic film can be displayed by another view, which often provides greater detail. For example, the panoramic film is often used to visualize impacted third molars. A lateral oblique view of the jaws provides the same information with greater detail. A Waters view provides greater information about the maxillary and other sinuses than a panoramic film.

39. Which intraoral view is best for visualizing the greater palatine foramina?

The greater palatine foramina cannot be visualized on any intraoral film. On some maxillary ocelusal films, a foramen can be seen in the area of the second or third molars. This foramen is the nasolacrimal canal and not the greater palatine foramen.

40. What are the names of the major salivary glands? How are they studied radiographically?

The three major salivary glands are the parotid, submandibular, and sublingual glands. Because the salivary glands consist of soft tissue, they cannot be seen on radiographs unless special steps are taken to make them visible. In a technique called sialography, a radiopaque dye or contrast is injected through the duct openings into the gland. Iodine is the agent normally used to provide contrast. Calcifications of the duct may be seen on intraoral films, especially calcifications of Wharton's duct, the submandibular gland duct. The stones or sialoliths may be seen on either periapical or more commonly on occlusal films.

41. What are the contraindications to sialography?

As stated above, iodine compounds are normally used as the contrast medium. It cannot be used, however, in allergic patients. In such patients, another contrast agent must be used.

42. What are the typical magnifications of radiographs commonly used in dentistry?

The magnification of periapical and bitewing films is about 4%; of cephalometric films, about 10%; and of panoramic films, 20—25%.

43. What are the indications for the use of MRI vs. CT?

There is no simple answer to this question. In general, MRI is better for imaging lesions based in soft tissues—for example, a tumor in the tongue. CT, on the other hand, provides better images of bone; thus, for an intraosseous tumor, CT is the technique of choice. Not uncommonly one may want to use both MRI and CT. For example, when a patient has a tumor in the floor of the mouth, one may use MRI to determine its extent in the soft tissue and CT to determine whether there is any bone involvement. For TMJ imaging, MRI is better at imaging the soft tissue of the disk, but CT is better for almost all other investiagions of the TMJ.

BASIC RADIOLOGIC INTERPRETIVE CONCEPTS

44. What are the radiographic features of any lesion or area of interest on the film that always should be defined and recorded?

1. Location of the lesion as exactly as possible
2. Size
3. Shape
4. Appearance of borders
5. Density, with particular attention to whether it is radiolucent, radiopaque, or mixed
6. Effects of the lesion on adjacent structures

45. Once the radiographic features of the area of interest are described, what is the first decision to be made about that area?

The first and most important determination is to decide whether the area is normal or abnormal. Simple as it may sound, this determination is the biggest challenge that you will face on a daily basis in clinical practice.

46. What is by far the most likely interpretation of a bilaterally symmetric radiographic appearance in the jaws?

A bilateral symmetric appearance, with extremely few exceptions, is indicative of normality. Among the few exceptions to this rule are cherubism and infantile cortical hyperostosis (Caffey's disease).

47. The location of a lesion may be a clue to its origin. What single anatomic structure in the mandible is most useful in differentiating between a lesion of possible odontogenic vs. nonodontogenic origin?

The mandibular or inferior alveolar canal is extremely useful in distinguishing between a lesion of odontogenic vs. nonodontogenic origin. Because one does not expect to find odontogenic tissues below the canal, it is most unlikely that lesions situated below the canal are odontogenic in origin. Indeed, the lesion of odontogenic origin rarely, if ever, begins below the canal. Of course, any lesion, including one of odontogenic origin, may begin above the canal and extend below it.

48. What is the most likely tissue of origin for a tumor in the mandibular canal?

Because a nerve and a blood vessel run in the canal, the tissue of origin is most likely to be either neural or vascular, resulting in tumors such as neurolemmoma, neurofibroma, traumatic neuroma, or hemangioma.

49. What broad categories of possible disease entities need to be considered in developing a differential diagnosis of any abnormality noted during a radiographic examination?

- Trauma
- Metabolic, nutritional, and endocrinologic diseases
- Congenital anomalies and abnormalities of growth and development
- Iatrogenic lesions
- Neoplastic diseases (benign and malignant)
- Inflammation and infection

50. What general radiographic features or principles permit the diagnosis of an underlying systemic cause for a particular condition or appearance?

When a systemic cause underlies a problem, both the mandible and maxilla are affected. Furthermore, the jaws are typically affected bilaterally, often symmetrically. If the condition affects the teeth, one would expect them to be affected in a bilaterally symmetrical fashion, too.

51. What technique can be used to determine the track of a fistula that exits on the soft tissue adjacent to the teeth?

Insert a gutta percha point into the fistula, and allow it to track as far as it can. Obtain a periapical view with the gutta percha point in place.

52. What are the usual radiographic signs of inflammatory disease involving the paranasal sinuses?

- Mucous membrane thickening
- Air-fluid levels
- Opacification of a sinus cavity
- Presence of a soft-tissue mass
- Changes in the cortical margins of a sinus

53. What common radiographic signs help to distinguish among a cyst, benign neoplasm, or malignant neoplasm?

Cysts tend to be radiolucent and round or oval in shape and to have intact cortical margins. Benign neoplasms are more variable than cysts in density, shape, and definition of margins. Malignant neoplasms of the jaws tend to be aggressive, with ragged margins and poor definition of shape and borders. Malignant lesions often grow quickly, leaving roots of teeth in position and giving the appearance of roots floating in space. Both cysts and benign neoplasms are more likely than malignant neoplasms to resorb tooth roots.

54. When should bitewing views first be obtained for the typical child?

The first bitewing views should be obtained after the establishment of contacts on the posterior teeth.

55. How do primary teeth differ from permanent teeth radiographically? How does the difference affect the radiographic evidence of caries in primary teeth?

Primary teeth are smaller and have relatively larger pulp chambers with pulp horns in closer proximity to the external surface of the crown. The enamel layer is thinner in dimension. Primary teeth are slightly less opaque on film because of a higher inorganic content. As a result, caries in primary teeth tends to progress more rapidly from initial surface demineralization to involvement of the dentin. Thus careful interpretation is especially important in evaluating the primary dentition.

56. What is the correlation between the histologic and radiographic progress of dental caries?

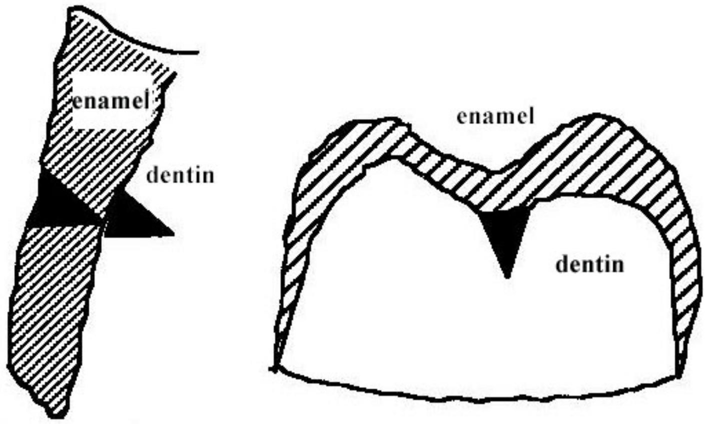
There must be 30—60% loss in mineralization before caries is radiographically evident with standard D- and E-speed intraoral films. Therefore, the histologic or clinical progress of a carious lesion is advanced, sometimes significantly, compared with its radiographic progress.

57. What is the rule of 3's for radiographic assessment of the development of permanent teeth?

It takes approximately 3 years for a permanent tooth bud to calcify after matrix formation is complete, approximately 3 more years for the tooth to erupt after calcification is complete, and about 3 more years after initial eruption for root formation to be complete.

58. What is the difference in the progress of pit and fissure caries and proximal or smooth surface caries on a radiograph?

In smooth surface caries in enamel the base of the triangle is at the surface, whereas the apex is at the amelodentinal junction. Once smooth surface caries penetrates, it spreads rapidly along the amelodentinal junction so that the base of the triangle is now at the amelodentinal junction and the apex is directed towared the dentin. Pit and fissure caries are not usually visible radiographically until the caries has reached the dentin. Pit or fissure caries then have a triangular appearance with the base of the triangle at the amelodentinal junction and the apex directed toward the deeper surface of the tooth.



Smooth surface caries Pit and fissure caries

59. In pathology of the maxilla, what feature is most useful in determining whether the pathology arose inside or outside the sinus?

The floor of the sinus is the most useful feature. If the pathology arose inside the sinus, the floor is intact and in its normal position or perhaps depressed inferiorly. If the pathology arose outside the sinus, the floor of the sinus is intact and in its normal position or moved or pushed superiorly. If the sinus floor has been destroyed, it may not be possible to determine whether the pathology arose from without or within the sinus.

60. Foramina may be superimposed over the apices of teeth, mimicking the presence of periapical disease. What radiographic features are most useful in distinguishing between normal structures and apical pathology?

If the lucency is due to the superimposition of a foramen, the periodontal ligament space and the lamina aura around the tooth are intact. The exposure of a second radiograph, with the tube in a different position from the first exposure, also is frequently useful. If the lucency moves relative to the apex of the tooth, the lucency is not associated with the tooth and is not due to periapical pathology. This exercise, however, does not rule out the possibility that the lesion is abnormal; it means merely that the lesion is not related to the tooth.

61. A radiolucency normally surrounds the crown of an unerupted tooth. What is it called?

The radiolucent area is called the follicle space.

62. Is it possible for a patient to be in acute pain as a result of a periapical abscess, yet to have a completely normal periapical film?

This finding is not unusual because 30—60% of mineralization must be lost before bone destruction is radiographically evident. In an acute situation, there frequently has not been sufficient time for this amount of bone destruction to occur. Thus, the radiographiags behind the clinical picture. The same may be true in the healing phase. A patient may be improving clinically yet still show radiographic signs of pathology.

63. Is a widened periodontal ligament space at the apex of a tooth always indicative of pathology?

No. When a radiolucency such as the mental foramen or mandibular canal is superimposed over the periodontal ligament space, the ligament space appears to be widened. Such a widening is purely artifactual. The periodontal ligament space also may appear wider at the neck of a tooth. If the lamina aura is normal in this area, the widened periodontal ligament space is probably a variant of normal.

64. Can a patient refuse an x-ray examination that is considered necessary, given signs and symptoms, and sign a release of responsibility in the chart?

A patient may legally refuse to undergo a radiographic examination. Such patients probably waive their right to seek damages later if an adverse event occurs that may have been detected by the radiograph. The patient's decision to refuse a radiographic examination is a matter of informed consent. The dentist may not be protected from suit if the record reflects merely that the patient was told of the need for an x-ray and declined to undergo the examination. The record should show clearly that the patient was told why the examination was necessary, what information the dentist needed, and how the lack of that information may lead to improper diagnosis and/or treatment.

65. What are the radiographic manifestations in the jaws of patients infected with the human immunodeficiency virus (HIV)?

There are no unique oral or maxillofacial radiographic manifestations of HIV infection, although infected patients are at a significantly higher risk for aggressive periodontal disease.

66. What is the efficacy of dental radiographs?

Studies of standard dental radiography (bitewing. periapical, and panoramic views) show considerable variance in the ability to detect common dental diseases such as caries, periodontal disease, and apical periodontitis. Radiographs should not be considered to be perfect, but they are most valuable when combined with a thorough history and clinical examination.

RADIOGRAPHIC INTERPRETATION

67. What is the earliest radiographic sign of periapical disease of pulpal origin?

The earliest radiographic sign is widening of the periodontal ligament space around the apex of the tooth.

68. What is the second most common radiographic sign of periapical disease of pulpal origin?

The second most common radiographic sign is loss of the lamina aura around the apex of the tooth.

69. Describe the radiographic differences that allow one to distinguish among periapical abscess, granuloma, radicular (periapical) cyst, and an apical surgical scar.

One cannot distinguish among periapical abscess, granuloma, or radicular (periapical) cyst on radiographic grounds alone. All of these lesions are radiolucent with well-defined borders. Whereas an abscess may be expected to be less well corticated than a radicular cyst, this feature is not marked or constant enough to be of real utility. An apical surgical scar may be radiographically distinguishable from the other three lesions if there is radiographic evidence of surgery, such as a retrograde amalgam. Of course, a history should elicit the fact of surgery.

70. How does the radiographic appearance of pulpal pathology that has extended to in volve the bone differ in primary posterior teeth from the picture commonly seen in perma nent posterior teeth?

In permanent teeth, widening of the periodontal ligament space is seen around the apex of the tooth. In primary teeth, by contrast, the infection presents as widening of the periodontal ligament space or an area of lucency in the furcation area.

71. Does any radiographic sign permit the diagnosis of a nonvital tooth?

It is frequently stated that tooth vitality cannot be determined by radiographs alone, but this is not so. The presence of a root canal filling in a tooth provides virtually conclusive proof of its nonvitality, as does the presence of a retrograde filling, usually amalgam.

72. At times it may be difficult to distinguish between hypercementosis and condensing or sclerosing osteitis around the apex of a tooth. What radiographic feature permits a definitive diagnosis when one is confronted with this dilemma?

If hypercementosis is present, the periodontal ligament space is visible around the added cementum; that is, the cementum is contained within and is surrounded by the periodontal ligament space. Condensing osteitis, by contrast, is situated outside the periodontal ligament space.

73. What is the radiographic sign of an ankylosed tooth?

The radiographic sign of an ankylosed tooth is loss of the periodontal ligament space and lamina aura.

74. What is the earliest radiographic sign of periodontal disease?

The earliest radiographic sign of periodontal disease is loss of density of the crestal cortex, which is best seen in the posterior regions. In the anterior part of the mouth, the alveolar crests lose their pointed appearance and become blunted. In the posterior areas, the alveolar crests usually meet the lamina aura at right angles. In the presence of periodontal disease, these angles become rounded.

75. What is the earliest radiographic sign of furcation involvement due to periodontal disease? In periodontal disease, one may see the loss of a cortical plate, either the buccal or lingual

plate, on an intraoral film. The plate may be lost so that the crest now occupies a position apical to the furcation. This appearance, however, does not permit a diagnosis of furcation involvement. Widening of the periodontal ligament space in the furcation area is the earliest radiographic sign of furcation involvement.

76. What is the radiographic differential diagnosis of a radiolucency on the root of a peri odontally healthy tooth?

Internal resorption, external resorption, and superimposition are the most common causes. Note that the question refers to a periodontally healthy tooth. If bone loss has resulted in exposure of the root, caries and abrasion, among other potential possibilities, enter the picture.

77. How can you distinguish among the above radiolucencies on the root of a tooth?

In internal resorption, the canal is widened, whereas it is unaffected in external resorption. If the resorption began below the bone level, it has to be internal resorption because, without adjacent bone, there are no osteoclasts in the area to cause external resorption. Of course, if either internal or external resorption involves both the canal and other tooth structure, it is not possible to distinguish between the two conditions. A superimposed radiolucency moves relative to the root if another view is obtained with the tube in a different position. The most common such lucencies are normal anatomy, such as foramina, sinus, mandibular canal, and accessory or nutrient foramina or canals. Artifacts such as cervical burnout also may produce a lucency on the root at the junction of the enamel and cementum.

78. What is the radiographic differential diagnosis of a radiolucency on the crown of a tooth?

Caries, internal resorption, restorations, abrasions, erosions, and enamel hypophisia are among the more common possibilities. Caries typically have irregular margins; they may also have typical shapes, such as the triangular appearance of interproximal caries. Internal resorption has smooth, well-defined margins. The same is true of radiolucent restorations, which frequently can be recognized by their shape and sometimes by the presence of an opaque base, such as calcium hydroxide, lining the floor of the preparation. Abrasions, particularly at the cervical margins, often have a V-shaped appearance. Other abrasions, such as those caused by a clasp on a denture, typically have well-defined borders and straight lines, unlike most naturally occurring phenomena. Erosions also have well-defined borders, and their shape is typically round or oval. Hypoplasia usually is not a single lucency on a tooth but rather many small lucencies.

79. What is the differential diagnosis of a root that appears short on the radiograph?

A root that appears short may indicate an incompletely formed tooth, which may be either vital and still developing or nonvital; a short but otherwise normal root (the root may be congenitally short or underdeveloped because of an acquired condition such as radiation); root resorption; foreshortening; surgery, such as apicoectomy; or iatrogenic causes, such as orthodontic treatment. In certain conditions, such as dentinogenesis imperfecta, the teeth also have short roots.

80. How can one distinguish among the various possibilities for a radiographically short- appearing root?

In a normal root, the canal is not radiographically visible to the apex nd appears to end just before the apex. In the case of a foreshortened normal root, the canal is not open at the apex. Foreshortening can be distinguished from a normal short root by the fact that other structures in the radiograph point to the steep angulation of the tube. Alternatively, a second film can be exposed to ensure that the correct vertical angle is used. If the root still looks short, it cannot be due to foreshortening. In teeth with an open apex, the shape of the canal is important. In a still-developing tooth, the ends of the canal diverge ("blunderbuss"), whereas in resorption the walls of the canal converge. Surgical intervention is usually easily spotted by the presence of a retrograde amalgam. The involvement of multiple teeth with short roots points to a condition such as dentinogenesis imperfecta. A history of orthodontic treatment confirms an iatrogenic cause.

81. What is the differential diagnosis for teeth with pulps that are reduced in size?

In dentinogenesis imperfecta all of the teeth are involved. In dentinal dysplasia all or or only some of the teeth may be involved. Less commonly, reduced chambers may be seen in amelogenesis imperfecta. Rarely, the cause of a generalized reduction in pulp size in many teeth may be idiopathic, although such cases are usually limited to a few teeth. The same is true of small pulp chambers due to attrition or trauma. Finally, small pulp chambers may be a variant of normal.

82. What conditions should be considered in a differential diagnosis of generalized large pulp chambers?

Any condition that results in a disturbance in calcification of the tooth may result in enlarged pulp chambers, including vitamin D-resistant rickets, hypophosphatasia, cystinosis, and hypoparathyroidism.

83. What are the radiographic signs of osteomyelitis?

A classic sign of osteomyelitis is a periosteal reaction or periostitis, which is typically seen in the mandible but rarely, if ever, in the maxilla. The periosteum lays down bone on its deep aspect, resulting in new bone, known as an involucrum formation. Cloacae, which are drainage tracts for purulent material, may be visible on radiographs. Sequestra, which are areas of bone separated from adjacent bone, are another typical feature.

84. What radiographic features help to differentiate a malignant lesion from osteomyelitis?

Malignant lesions destroy bone uniformly. In osteomyelitis, areas of radiographically normal-appearing bone are frequently seen between the areas of destruction. Sequestra are not present in malignant lesions. The nature of the periosteal response cannot be used to distinguish between malignancies and infection, with the possible exception of the sun-ray periosteal reaction described in osteogenic sarcoma.

85. What features of a periosteal reaction help to differentiate between infectious periosti tis and a periosteal reaction due to malignant disease?

A periosteal reaction by itself does not permit a definitive diagnosis of either an infectious or malignant origin, notwithstanding comments to the contrary. Although some periosteal reactions are more suggestive than others of a particular origin (e.g., the sun-burst appearance of osteogenic sarcoma), none is definitive.

86. Both fluid and a soft tissue mass present as opacification of the maxillary sinus on a Waters view. How can one distinguish radiographically between the two?

Take a second view with patient's head tilted upward, downward, or laterally relative to the position for the first Waters view. If the superior border of the opacity remains the same, one is dealing with soft tissue. If the superior surface changes, one is dealing with fluid because the fluid level changes when the head is tilted (like water in a glass). This technique, of course, does not work when opacification of the sinus is complete. One cannot distinguish between fluid or soft tissue in the sinus on the basis of the degree of opacity on plain films.

87. Sometimes it is difficult to distinguish a tooth or part of a tooth embedded in bone from other opacities in the bone or from opacities in the sinus. What radiographic features are helpful in this predicament?

An opacity surrounded by a thin, relatively uniform radiolucent zone, which in turn is surrounded by a thin radiopaque line or cortex, is of inestimable value. The radiolucent zone and cortex provide conclusive proof that the opacity is not in the sinus. The uniform zone is suggestive of the periodontal ligament space, whereas the cortex is suggestive of the lamina aura. This general appearance is thus reminiscent of a tooth. The presence of a canal in the opacity is also useful. Whether the opacity is in fact tooth depends, among other things, on the density and uniformity of the opacity as well as on its shape and size. An odontoma, for example, has the general features of uniform radiolucent zone, surrounded by a cortex, yet it is a benign tumor. One may not be able to determine with certainty from a periapical view alone whether an opacity is inside or outside the sinus. A Waters view helps to clarify the situation.

88. List the radiographic signs of a fractures.

The radiographic signs of a fracture include a demonstrable radiolucent fracture line, displacement of a bony fragment, disruption in the continuity of the normal bony contour, and increased density (due to overlap of the adjacent fragments).

89. What radiographic sign helps to differentiate between a recent fracture and an older fracture?

The edges of an older fracture are typically rounded, whereas the edges of a recent fracture are sharp.

90. What plain film views are of greatest assistance in evaluating the jaws for fractures?

The Waters view provides the single best plain film view of the maxilla. The zygomatic arches are best examined with a basal or submentovertex view. A PA film of the mandible is helpful, as are lateral oblique films. Occlusal views are useful in both the mandible and maxilla. Periapical films provide the greatest detail about a fracture if the fracture line traverses an area that a periapical film is able to cover. A reverse Towne projection shows the condylar necks and condyles, as does the transorbital or periorbital view.

91. What radiographic features help to differentiate between the radicular cyst emanating from a maxillary central incisor and the nasopalatine or incisive canal cyst?

If the lesion crosses the midline, it is far more likely to be a nasopalatiño intact lamina aura around the teeth is indicative of vital teeth and effectively rules out a radicular cyst. The presence of large restorations on a central incisor supports the diagnosis of a radicular cyst, but this feature is overridden by an intact lamina aura.

92. To what extent do the amount and degree of calcification in a tumor point to its benign or malignant nature?

Calcification has no significance in predicting the benign or malignant nature of a tumor. Both benign tumors (e.g., odontomas, adenomotoid odontogenic tumors, ossifying fibromas) and malignant tumors (e.g., osteogenic sarcoma produce bone or calcifications. To determine the benign or malignant nature of a tumor, one must look to other features.

93. Which lesions may present with a soap-bubble or honeycomb appearance?

Ameloblastoma
Keratocyst
Primordial cyst
Aneurysmal bone cyst
Cherubism
Giant cell lesions
Hemangioma
Calcifying epithelial odontogenic tumor
Fibrous dysplasia

94. What are the radiographic features of degenerative joint disease (DJD) or osteoarthri tis involving the TMJs?

The changes of DJD include subchondral sclerosis, flattening of the articular surfaces of the condyle, and osteophyte formation. Osteophyte formation occurs in the later stages of the disease process. Small erosions, called Ely cysts, may be seen on the articulating surfaces. A narrowing of the joint space is another common finding. The eminence may be flattened or hollowed and may also show osteophyte formation.

95. Why is it important to visualize both TMJs on radiograph even when a patient has signs and symptoms only on one side?

The unique nature of the TMJs—both are part of a common mandible—often results in functional symptoms on one side even though the osseous pathology may be on the other side. Once the decision to radiograph a joint has been made, both sides should be examined.

96. What common intracranial calcilications may be observed on a radiographic view of the skull, such as a cephalometric view? What intracranial calcilications represent pathology and should be further evaluated?

Physiologic calcifications include those of the pineal gland, choroid plexus, aura (falx cerebri, tentorium, vault), ligaments (petroclinoid, interclinoid), habenular commissure, basal ganglia, and dentate nucleus. Pathologic calcifications include calcifications in tumors (meningioma, craniopharyngioma, glioma), cysts (dermoid cyst), and infections (parasitic, as in cysticercosis; tuberculosis).

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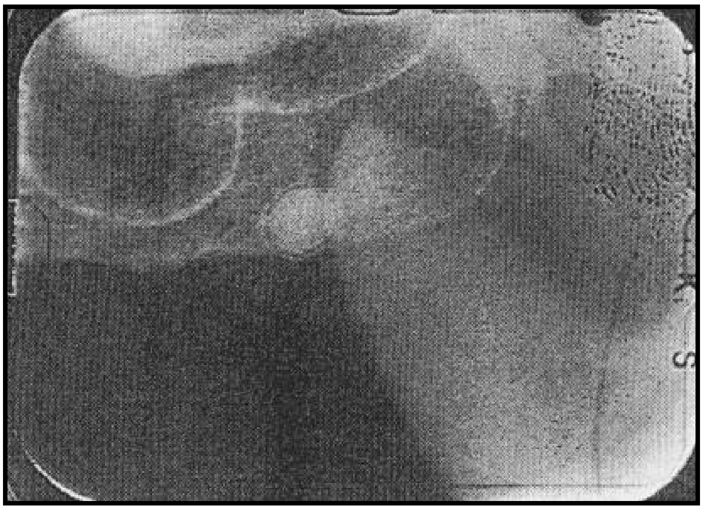
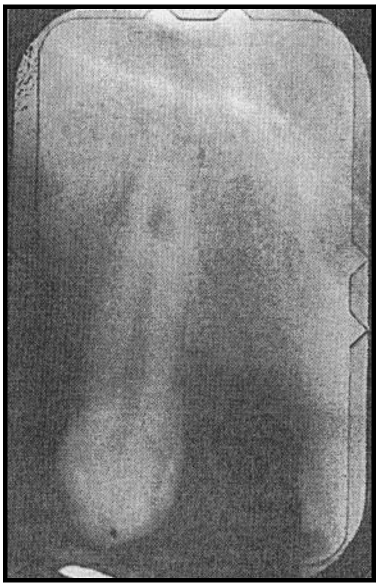
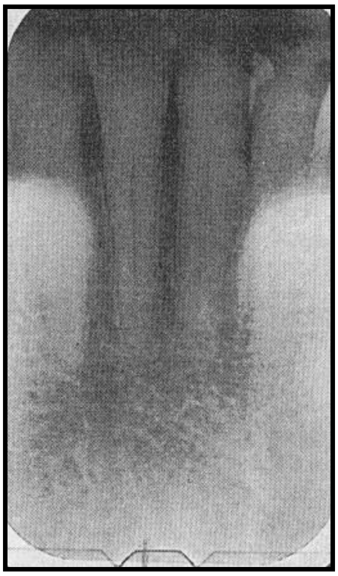
ILLUSTRATIONS



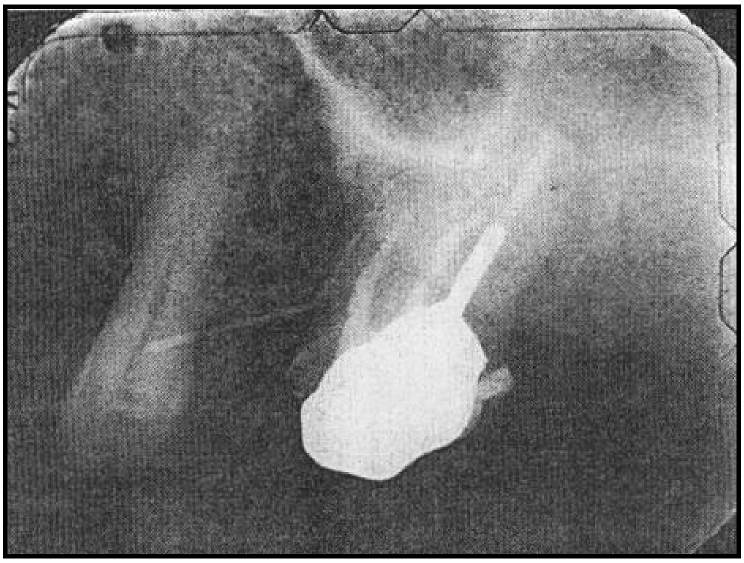
Root. A small, rounded, uniformly opaque structure is visible in the left posterior maxilla. The opacity is surrounded by a small, uniform radiolucent zone, which in turn is surrounded by a thin, uniform radiopaque line or cortex. The radiopacity is reminiscent of tooth structure, the radiolucent zone of the periodontal ligament space, and the cortex of the lamina aura. This radiographic appearance is virtually diagnostic of a tooth—in this case, a root that remained following extraction of a tooth. The triangular opacity is a normal structure, the coronoid process of the mandible.



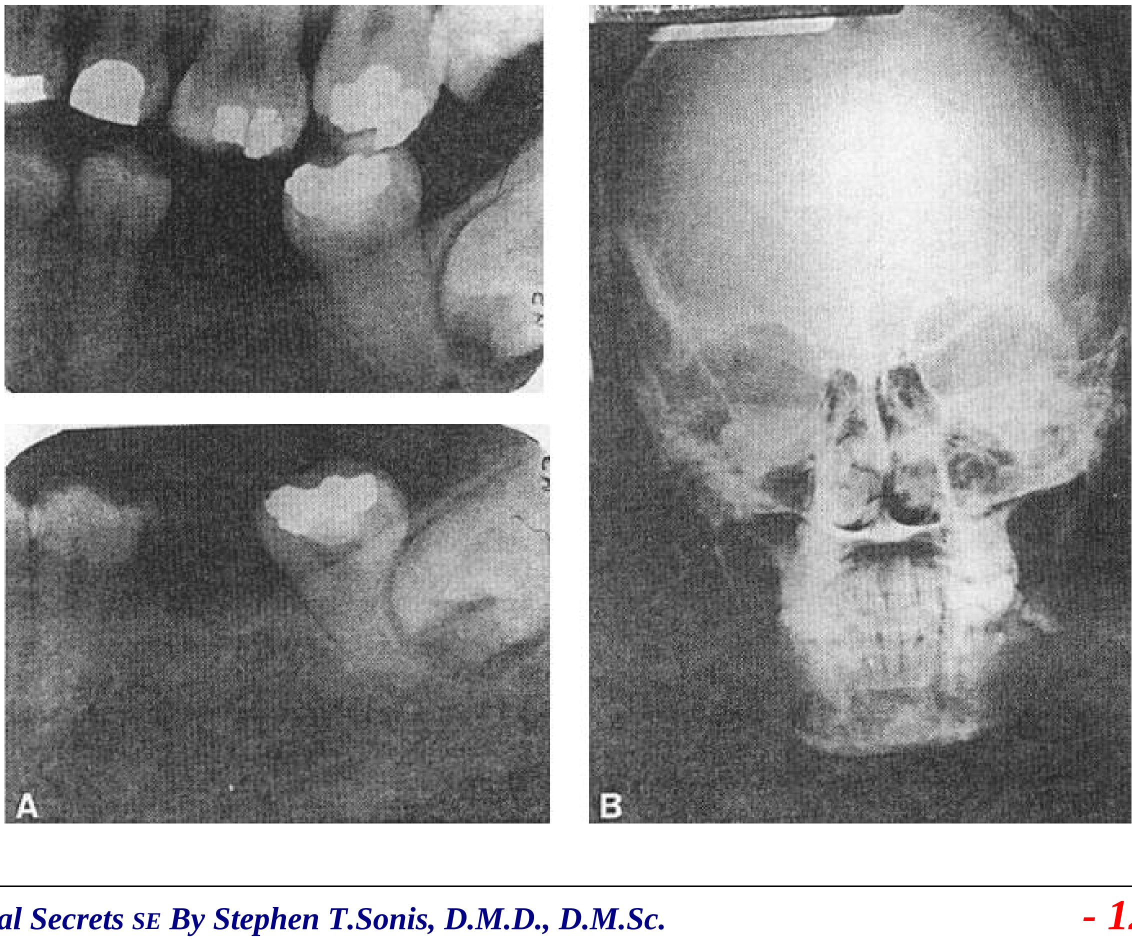


Left, **Radiolucency on root of a tooth.** This radiograph shows an example of extemal resorption. Note the intact canal, eliminating internal resorption as a possible cause. Other causes of a radiolucency on the root of a tooth include superimposition, caries, abrasion, and radiolucent restorations.
Right, **Tori.** Symmetrical opacities are visible in the premolar region of the mandible. The posterior borders of the opacities are not visible on the films; the anterior borders, however, are

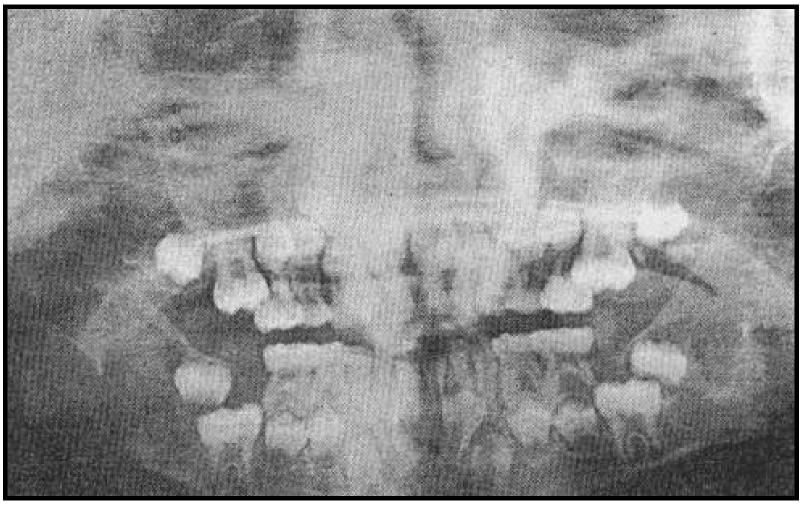
well defined. The teeth are unaffected by the opacities. The appearance is due to the presence of lingual tori. This radiograph illustrates the principle that bilateral, symmetrical opacities are, with rare exceptions, normal or variants of normal.



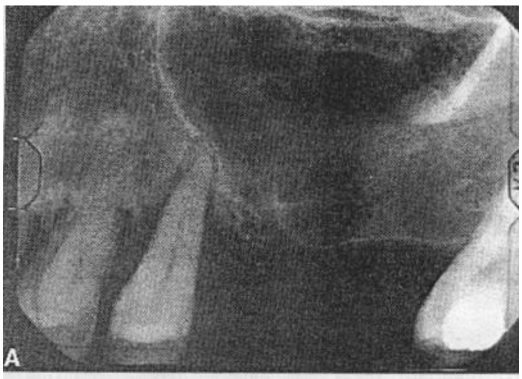
Fistulous tract. The patient presented with a complaint of pain in the left posterior maxilla. Clinical examination revealed drainage from the buccal sulcus around tooth no. 15. To determine the origin of the problem, a gutta percha point was inserted and a film exposed. Rather than being purely peri odontal, the problem emanated from the apex of the mesiobuccal root.

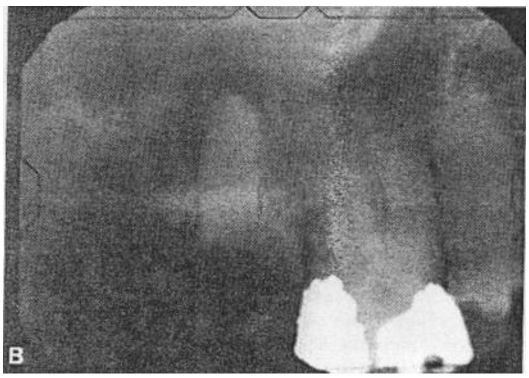


Buccal object rule. The radiographs above illustrate the buccal object rule. Bitewing and periapical films (A) show an impacted third molar on the left side. For the periapical exposure, the cone was moved distally in relation to the bitewing view. The impacted third molar moved mesially, that is, in the opposite direction in which the tube was moved. Applying the principles of the buccal object rule, we can determine that the impacted third molar lies buccal to the erupted second molar. The posteroanterior mandibular view (B) confirms this deduction. Note that in order to apply the rule, one must have a reference object—in this case, the erupted second molar.

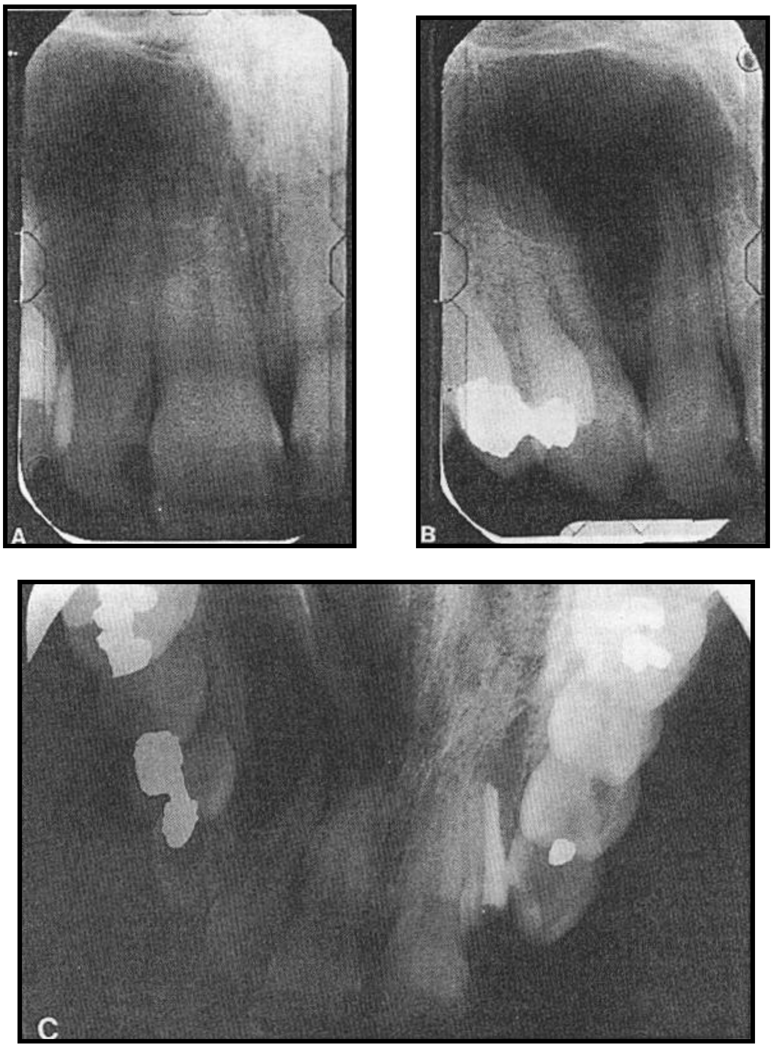


Cherubism. The panoramic radiograph above shows symmetrical, bilateral, multilocular radiolucent areas in the mandibular ramus. This is one of the rare exceptions to the general statement that symmetrical bilateral ap pearances are normal or variants of normal. The appearance indicates cheru bism. Another exception to the general statement is infantile cortical hyperostosis or Caffey's disease.

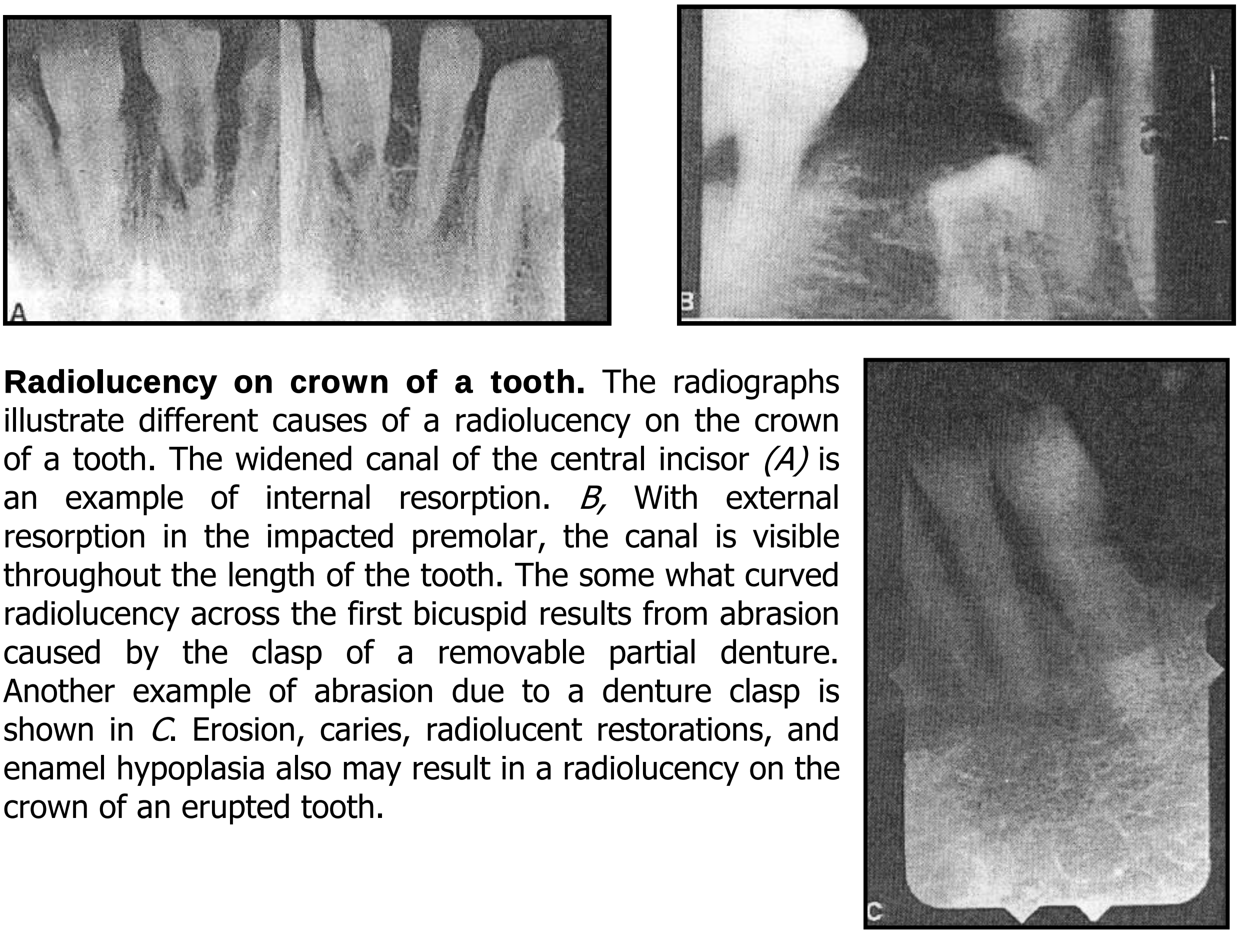




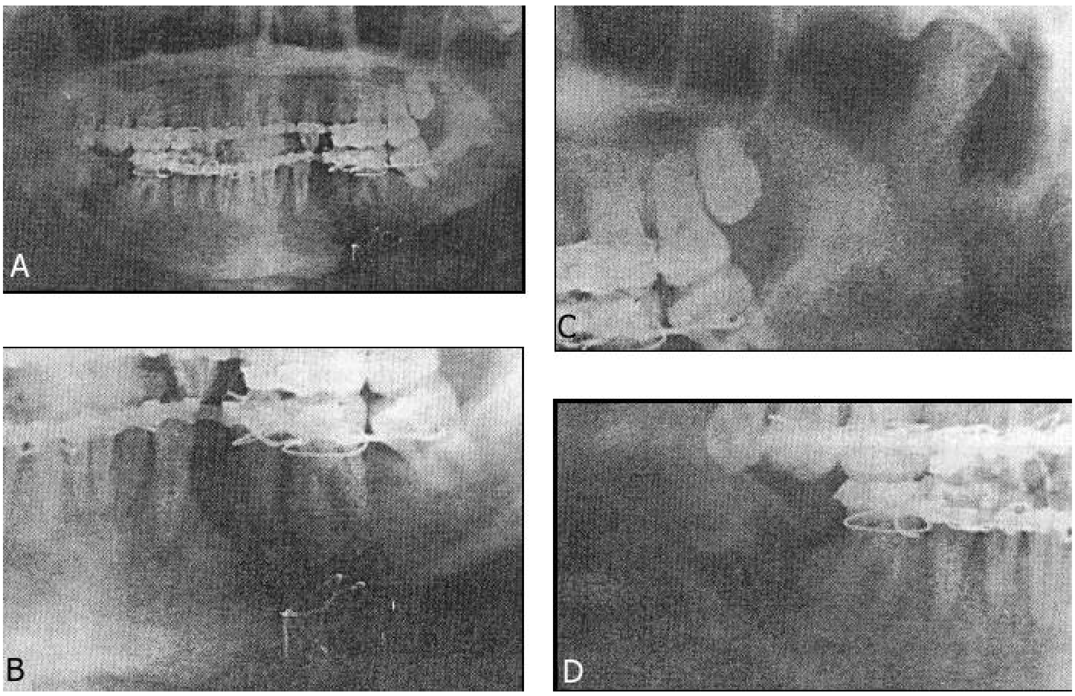
Pathology arising from within or without the sinus. The periapical radiograph *(A)* shows a dome-shaped opacity situated apical to the area of tooth no. 15. The well-defined and uncorticated opacity is situated above the sinus floor, which is intact. The intact sinus floor strongly suggests that the opac ity arose inside the sinus rather than outside with subsequent invasion of the sinus. The radiographic appearance is consistent with a mucous retention phenomenon. The apical view *(B)* shows a radiolucent area apical to the root of tooth no. 2. The sinus floor is el evated but intact. This appearance suggests that the problem originated outside the sinus and is consistent with rarefying osteitis and a concomitant periostitis, which occurs as the floor of the sinus attempts to confine the lesion by continually reforming. If the sinus floor is destroyed, it may be difficult and sometimes impossible to determine whether the lesion arose from within or without the sinus.



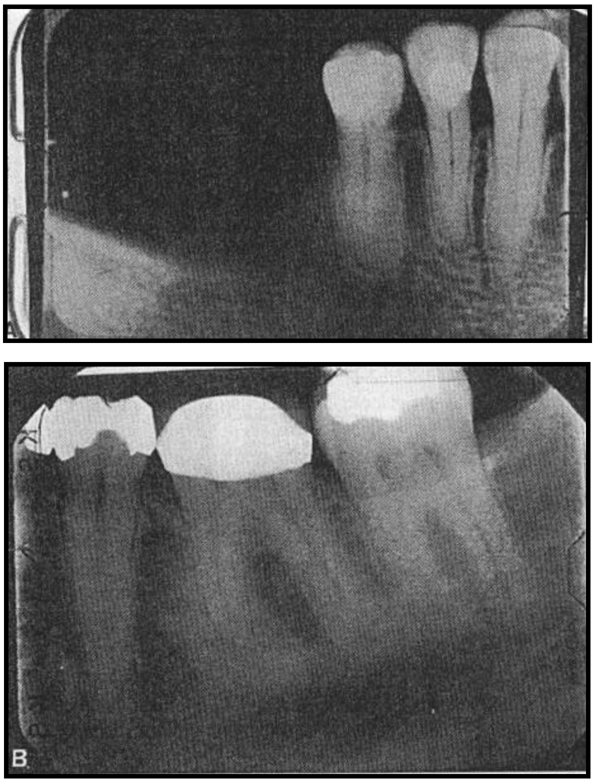
Radicular cyst. The large radiolucency in the right maxilla illustrates a radicular cyst arising from tooth no. 7. The lucency is well defined and partly corticated, features that are consistent with a benign lesion. The cortical borders of the sinus and nasal cavity are intact. Note that the lucency does not cross the midline. Another entity that should perhaps be considered is an incisive canal or nasopalatine cyst. With rare exceptions, however, the nasopalatifle cyst crosses the midline.



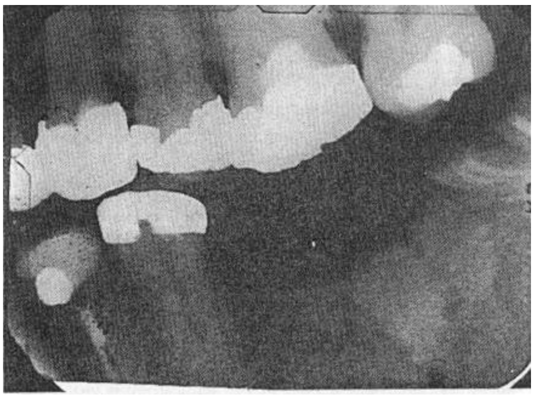
Radiolucency on crown of a tooth. The radiographs illustrate different causes of a radiolucency on the crown of a tooth. The widened canal of the central incisor *(A)* is an example of internal resorption. *B,* With external resorption in the impacted premolar, the canal is visible throughout the length of the tooth. The some what curved radiolucency across the first bicuspid results from abrasion caused by the clasp of a removable partial denture. Another example of abrasion due to a denture clasp is shown in *C*. Erosion, caries, radiolucent restorations, and enamel hypoplasia also may result in a radiolucency on the crown of an erupted tooth.



Fractures and osteomyelitis. The most obvious abnormality is the fracture in the premolar area of the left mandible (*A* and *B*). Also evident is a fracture of the right body of the mandible. Although single fractures of the mandible do occur, it is highly common for more than one to be present. Closer examination reveals that the left condyle also has sustained a fracture (*A* and *C*). More often than not, unilateral fracture of the condyle is associated with a fracture of the opposite side of the body of the mandible. Perhaps the greatest concern to the patient is the presence of osteomyelitis in the right body (*A* and *D*). This case illustrates eloquently a highly specific feature of osteomyelitis: the more or less rounded opacity surrounded by a radiolucent zone. The rounded opacity, situated at the inferior cortex, is a sequestrum. A larger. boat-shaped sequestrum is visible inferior to and partly surrounding the round sequestrum. This panoramic film illustrates a cardinal point: always examine the entire film. Once you have spotted an area of interest, be certain to examine the rest of the film. If necessary, cover the previously examined area so that your attention is not continually drawn to it.



Hypercementosis and condensing osteitis. *A,* Enlarged root of tooth no. 29, particularly in the apical area. The root of tooth no. 28 also shows some widening. The periodontal ligament space surrounds the tissue that has been laid down, and the lamina aura is visible outside the periodontal ligament space. *B,* An opacity situated outside the periodontal ligament space is situated. A illustrates hypercementosis, whereas B is an illustration of condensing osteitis.



Extraction sockets. The appearance of a healing or healed extraction socket may present a problem. The sockets shown above have filled with dense bone. In some cases, such an appearance may be confused with a root. Features that may be of assistance in distinguishing between the two include the density of the socket, the presence or absence of a canal, and the presence or absence of a periodontal ligament space. Nonetheless, the diagnosis may be difficult. For a good discussion and illustration of the problem, see Worth HM: Principles and Practice of Oral Radiologic Interpretation. Chicago, Year-Book, 1963, pp