To simulate periodontal and periapical lesions, bone cuts were made in mandibles from human cadavers, and the roentgenographic and visual appearances of the bone were compared. It is evident that inflammatory or tumorous lesions cannot be visualized if they are confined within the cancellous bone. However, if the lesions erode the junction area of the cortex and cancellous bone or perforate the cortex, they can be distinguished roentgenographically. Early stages of bone disease cannot be detected by means of routine roentgenograms, nor can the size of a rarefied area on the roentgenogram be correlated with the amount of tissue destruction.

In a previous investigation (1) dealing with roentgenographic appearance of experimental lesions in bone it was observed that:

1. Bone lesions could be detected on the ordinary intraoral roentgenogram only if there was (a) a perforation, (b) extensive destruction of the bone cortex on the outer surface or (c) erosion of the cortical bone from the inner surface.
2. Lesions confined within the cancellous bone could not be seen on the roentgenogram.
3. The apparent cancellous destruction or loss of trabecular pattern that is visible on the roentgenogram is often due to an erosion of the innermost surface of the bone cortex at the junction area between cancellous and cortical bone.

These observations formed the basis for the following investigations which were designed to study the roentgenographic appearance of artificially created periapical and periodontal bone lesions.

Human mandibles and maxillae, obtained at necropsy, were studied. Experimental bone lesions of various types, simulating periapical and periodontal lesions, were created by dissecting cortical and cancellous bone with reamers, files, burs and stones.

Roentgenograms of the bone were taken before and after experiments. All roentgenograms were taken at the same target film distance and angulation. The films were exposed for two seconds at 65 kvp, 10 ma. and were developed together for three minutes for each study.

In addition, mandibles and maxillae were dissected to study the relation of the apical portion of the roots of various teeth to cortex and cancellous bone.

**EXPERIMENTS**

Artificial Periodontal Lesions

The alveolar crest was perforated and the cancellous bone was drilled with a no. 558 tissue bur to a depth of 15 mm. Roentgenograms revealed a break in the lamina dura only at the crestal area where perforation had occurred. There was no evidence of rarefaction in the experimentally drilled cancellous portion of the bone.

The buccal plate was cut to simulate an infrabony pocket. Roentgenograms were taken after successively deeper bone cuts. Gradations in rarefaction could be noted, depending on how much cortex had been removed. Rarefaction increased with an increase in the amount of cortex removed. When the entire buccal plate was removed the area appeared more rarefied. It was not possible to distinguish, roentgenographically, whether the lesion was on the buccal or lingual side. However, when both buccal and lingual plates were removed, simulating an infrabony pocket with no buccal or lingual wall, a sharp contrast in rarefaction could be seen on the roentgenogram. Removal of both buccal and lingual plates produced the most distinct area of rarefaction (Fig. 1).

These experiments showed that the intensity of the roentgenographic images cast by the infrabony pockets depends on the amount of cortical destruction. Clinical infrabony pockets could exist without roentgenographic evidence of rarefaction, particularly if a small amount of cortex is lost on the root surfaces of the buccal or lingual sides. Infrabony pockets that produce light roentgenographic shadows are probably caused by loss of the inner surface of cortical bone. Pronounced rarefaction, depicted by a very dark shadow around a tooth on the roentgenogram, probably indicates that the cortex has been destroyed from both buccal and lingual sides.
Artificial Periapical Lesions

A tooth was extracted with ordinary forceps from the mandible of a cadaver. An apical opening was made through the socket and reamers and files up to size no. 4 were introduced to a 5 mm. depth beyond the apex of the socket. Roentgenograms were taken. Burs in a gradation of sizes from no. 2 to no. 8 were then introduced into the bone through the apical opening and serial roentgenograms were taken with and without the instruments in place.

Fig 1. Periodontal lesions were duplicated by drilling through alveolar crest with a bur. A: Bone before experiment. B: Drilling through alveolar crest and through cancellous bone from mesial section. Area of rarefaction was produced by cutting through cortical plate. C: After drilling. D: Removal of buccal plate. E: Removal of buccal and lingual plate. F, G, and H: Photographs of bone specimen used in the experiment. Note the areas of denuded bone over the first bicuspid and the molar. This is not evident on the roentgenograms.
The roentgenograms revealed that no changes were produced by no. 4 reamers and files or by burs up to size no. 2. Changes of radiolucency were produced by the larger burs; the greater the bur size, the larger the areas of radiolucency. It appeared that the reamers and files destroyed cancellous bone only, hence changes were not detectible roentgenographically. When instruments which were wide enough to encroach upon the junction of cortex and cancellous bone were used, areas of rarefaction developed (Fig. 2).

Large burs produced roentgenographically observable effects because they encroached on the junction area, removed the trabeculae and eroded the inner surface of the bone cortex on the buccal or lingual side, or on both sides (Fig. 3).

**Relation of Root Apices to Cortical Plate**

Dissection of the mandible revealed that most of the root apices of the anterior teeth and the bicuspids were located in or near the buccal aspect of the cortical bone. In most bifurcated first molars, the mesial root was lodged near the buccal bone plate whereas the distal root was located in cancellous bone. In others, the distal root was embedded in the lingual bone plate. In most of the second molars, the root apices were suspended in the cancellous bone; in others the distal root was in proximity to the lingual plate. In some third molars the roots were lodged within or near the lingual bone plate; in others they were suspended in cancellous bone.

The apices of most teeth are lodged in or near cortical bone. Therefore, in most teeth the development of periapical lesions soon appears on roentgenograms because the lesions involve the cortex sooner. On the other hand, periapical lesions may not be disclosed around teeth whose root ends are not embedded in cortex until the lesions have developed to the extent that they reach the cortex. Then roentgenographic manifestations can be observed.

This close relation of root apex to buccal cortical plate may explain why fistulation occurs on the buccal side.
The encroachment of the root apices on the cortical portion of the bone could be seen in roentgenograms of cross sections of the specimens (Fig. 4). The mandible was narrowest at the root end, with an hour-glass constriction in the anterior and bicuspid region.

The thickness of the cancellous and cortical bone varied, depending on the various parts of the mandible. In some specimens, the cancellous bone was about 1/2 mm. thick between the cortical plates, whereas the cortical plates were about 4 mm. thick. Nevertheless the trabeculae could be visualized distinctly. The trabeculae appeared numerous and distinct even when there was a small amount of intervening marrow space. The trabeculae were especially noticeable around the lamina dura and in the region of the alveolar crest. In the region of the lower border of the mandible the cancellous bone was less dense. The cortex narrowed considerably in the region of the alveolar process. In a number of instances there was a denudation of the buccal cortical plate over or near the root apices. These denuded areas were not observed on the lingual plate (Fig. 1).

**CLINICAL CORRELATIONS**

Based on previous and currently reported studies some correlations with anatomic landmarks and clinical findings on bone lesions from local and systemic diseases can now be made.

**Anatomic Landmarks**

Anatomic landmarks, such as various foramina and canals can be visualized roentgenographically because the cortex is perforated. Nutrient canals are present in the cortex as minute tubes that exit on the surface of the bone. Therefore they, too, can be readily observed in roentgenograms.

**Bone Lesions Caused by Local Factors**

Roentgenograms frequently do not show any disease in acute alveolar abscesses even though a copious flow of blood and pus is
present. In these instances there is pronounced tissue destruction, but the destroyed tissue is cancellous bone. Inflammatory cells are substituted for marrow cells, a pathologic condition which does not show up on roentgenograms. In time, rarefaction develops and can be seen roentgenographically. This rarefaction results from a thickening of the periodontal membrane at the expense of the lamina dura. In this instance cortical bone is involved. The area of rarefaction develops and becomes more apparent when the trabeculae are resorbed at the junction of cancellous and cortical bone.

A large granulomatous mass is occasionally attached to a root end on tooth removal, even though an area of rarefaction was not visible on the roentgenogram. Examination of the preoperative roentgenogram reveals only a slight loss of the lamina dura. When this occurs at the apical end it does not always mean that the bone is only slightly involved. There may be extensive cancellous involvement which cannot be visualized roentgenographically.

In some teeth with acute pulp disease, regions of rarefaction develop rather quickly because the apical portions of the roots are embedded in or near the bone cortex. Hence the cortex is quickly eroded. Roentgenographic detection of apical involvement of palatal roots of molars is not very common. This may be because the palatal roots are encased in cancellous bone.

In a statistical analysis of 558 endodontically treated molars it was found that 314, or 57 per cent, were lowers; whereas 244, or 43 per cent, were uppers. The lower molars displayed areas of rarefaction in 91 instances, or an incidence of 29 per cent. There were 51 instances of areas of rarefaction in the upper molars, or an incidence of 20 per cent. This difference may exist partly because the lesions in the lower molars can be detected more readily on the roentgenogram because of more rapid cortical involvement.

The difference in apical and pulpal involvement between the upper and lower molars cannot be entirely ascribed to the anatomic relation of the apices of the roots to the bone cortex. The difference in caries incidence may also be a factor. It has been shown that there is a greater incidence of caries in the lower molars than in the upper molars (2).

It has also been observed that initial lesions which produce roentgenographic evidence of rarefaction occur more often on the mesial roots of lower first molars; in the later stages of inflammation, rarefaction develops around the distal root. Actually, all the roots are involved in the inflammatory process. The detection depends on the amount of cancellous bone present and the relation of the roots to the cortical plate. When the root is closer to the cortex the detection is more rapid.

The difference in the time of appearance of the lesions on the mesial and distal roots of lower first molars has been ascribed to the fact that the distal canal may have vital tissue present whereas in the mesial canal the pulp is completely necrosed. However, observations have been made in which both canals are necrotic and yet the lesions appears on the mesial root. If tissue breakdown were the only factor, then the distal root would exhibit the lesion first. This is because more tissue is present in the distal canal and a greater concentration of tissue degradation products would be present to produce an inflammatory response. Conversely, it has been observed that the pulp of the mesial root may be partially vital and the distal root completely necrosed, yet roentgenographic evidence of the lesion manifests itself first on the mesial root. A more accurate explanation may be based on the relation of the roots to the cortical plate.

Occasionally, areas of rarefaction are observed first on the apex of the distal root. This is usually seen when there is little bifurcation and the distal root is in proximity to the mesial root. In these instances there may also be a close relation between the distal root apex and the buccal plate.

Whereas the close relation of the roots to the buccal cortical bone may explain why fistulation occurs most often on the buccal side, infrequently a fistula occurs without the detectible roentgenographic bone changes. This occurs in the presence of a root that is denuded of labial or buccal cortical bone in the apical region. Therefore, the inflammatory process proceeds without destroying the adjacent bone cortex (Fig. 1). The authors do not subscribe to the idea that fistulation occurs as a result of lesser resistance.

On a roentgenogram, surgical removal of a tooth by removing the buccal plate invariably shows a distinct area of rarefaction. This occurs every time the cortex is removed. Roentgenographic examination after apical surgery also reveals radiolucent areas. Sometimes, although infrequently, bone regeneration apparently does not occur. In this condition (“operative defect”) the cortex has been removed but has not regenerated. Thus, the rarefaction persists on the roentgenogram.

### SYSTEMIC DISEASES INVOLVING BONE

In multiple myeloma the myeloma cells proliferate to form a myeloma cell tumor. In early stages the tumor may not be evident on roentgenograms, yet a sternal biopsy will invariably show the presence of myeloma cells in the cancellous bone. Roentgenographic changes are not seen until the cortex is infiltrated by cells, resorbed or perforated. This has been verified by studies of autopsy material. These disclose that where distinct, punched-out lesions have been found in roentgenograms, there was thinning or perforation of the cortex (3). The darker areas represented perforations and the lighter areas indicated erosion or a carious process in the cortex.

In the early stages of Gaucher’s disease, roentgenograms often do not show any disease. The diagnosis is usually confirmed by sternal biopsy. As the disease progresses the foam cells, which are characteristic of the disease, increase in number and size, invade the bone marrow and produce a pressure resorption of the trabeculae. As a result, the bones acquires a foamy appearance and there is a thinning of the cortex (4). Films then made with routine exposures indicate pronounced rarefaction. In later stages of the disease it is necessary to reduce the exposure time for roentgenographic examination because of the thinning of the cortex (5).

An increased deposition of cholesterol is found within the histiocytes in Hand-Schüller-Christian disease. Large granulomatous masses are produced which can be seen roentgenographically after they infiltrate the cortical area. Here, too, sternal biopsy confirms the early presence of the disease despite the absence of initial roentgenographic manifestation.

Early stages of metastatic bone carcinoma often cannot be detected by means of roentgenographic examination, even though the patient has symptoms of bone pain. As the disease progresses it destroys more of the marrow spaces and expands toward the junction area. It invades the cortex and produces lesions which appear on roentgenograms. Shackman and Harrison (5) have demonstrated that a patient may have extensive bone metastases without demonstrable roentgenographic bone abnormality.

There are many other diseases which produce rarefied changes in the skeletal system, but the changes can be observed easier roentgenographically if the cortex has been invaded. Initial confinement of the lesion to the cancellous portion of bone prevents roentgenographic visualization of the lesion.
DISCUSSION

From these and other experiments it is evident that by the methods ordinarily employed for taking roentgenograms, inflammatory or tumorous lesions cannot be visualized if they are confined within the cancellous bone. However, lesions can be distinguished on roentgenograms if they erode the junction area of the cortex and cancellous bone or perforate the cortex because cortical bone contains more calcium per unit of volume than cancellous bone.

The experimental conditions reported here are more critical than actual clinical conditions. Tissue fluids, inflammatory cells and exudate are present in clinical conditions, whereas under the experimental conditions the bone specimen did not have fluid present in the lesion.

In view of the experimental evidence presented, early stages of bone disease cannot be detected by means of routine roentgenograms. Moreover, the size of a rarefied area on the roentgenogram cannot be correlated with the amount of tissue destruction. A small area of rarefaction on a roentgenogram can be indicative of as much, or more, bone destruction as a large rarefied area.

SUMMARY

Mandibles from human cadavers were dissected and bone cuts were made to simulate periodontal and periapical lesions. Comparisons were made of the roentgenographic and visual appearance of the bone.

It was found that the artificial lesions could not be visualized on the roentgenogram if the lesions were confined within cancellous structure. If, however, the lesions were enlarged so they encroached on the junction area of the cancellous and cortical bone they could be seen on the roentgenogram. If sufficient bone tissue was removed to erode the inner surface of the bone cortex, the area became even more rarefied and discernible. Thus, it was shown that lesions produced by local diseases such as acute inflammation and systemic diseases of the skeletal system, including metastatic carcinoma, cannot be visualized easily on the roentgenogram if they are confined within the cancellous bone. Correlations were made of these findings with clinical bone lesions.

Dissections of the mandible and maxilla revealed that most root apices are in juxtaposition to the buccal cortex. The roots of lower third molars, in most instances, are in proximity to the lingual bone plate. The distal root of a bifurcated lower first molar, the roots of the lower second molar and most upper molars, particularly the palatal root, are encased in more cancellous bone.

A study of 556 endodontically treated molars revealed that more lower molars than upper molars exhibit areas of rarefaction. This variation may exist because the upper molars are encased in cancellous bone, hence the lesion cannot be readily visualized on roentgenograms. It could also be due to a greater caries incidence in the lower molars. Roentgenographic detection is not facilitated until expansion of the lesion with erosion of the innermost surface of the cortex occurs. However, roentgenograms cannot disclose whether the lesion is on the buccal or lingual side.

Further explanations have been made of the significance of these findings to various dental and systemic clinical conditions.

References