MESCHAN

Synopsis of Analysis of Roentgen Signs in General Radiology

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To the memory of our parents

Preface

The present text is intended as a synopsis of a three-volume text, which emphasizes "the compilation and illustration of major roentgen signs in general radiology, their classification and correlation with clinical diagnosis and practice."

This *Synopsis* will provide the student with a condensation of diagnostic radiology, a field which is so vast that, even in the three-volume text, choices had to be made, and certain omissions were necessary. In this *Synopsis,* therefore, the selectivity of content has been doubly abbreviated, and it is hoped that the student, resident, practitioner, or radiologist might use this book as an initial guide to the larger text whenever he deems it necessary.

An attempt has been made to standardize the classification of roentgen signs by cataloguing them, as far as possible by (1) changes in size, contour, density, number, architecture, both internal and external, function, and position, on the one hand, and (2) changes in relation to time and treatment on the other.

Such standardization, in my judgment, permits a student to study the radiologic signs of a patient more objectively, and thereafter, to amalgamate these findings with the clinical facts so that a more intelligent differential diagnosis may be achieved. It is conceivable that such standardization might lend itself eventually to computerization and to greater statistical study of the absolute significance of certain roentgen signs, which admittedly are now based on judgment and experience. This still presents a possibility for the future.

I have continued to use the "midget exhibit" technique in teaching; the questions at the end of each chapter permit the student an element of self-instruction to reinforce his knowledge.

The chapter bibliographies in the three-volume text have not been repeated here, since the student may obtain these volumes in most medical libraries if he so desires. This omission is, of course, a space and economy measure, necessitated by the severe restrictions involved in reducing three volumes to one.

Finally, in this *Synopsis,* we have tried to define, by thoughtful limitation of the material to be included, a "body of knowledge" or "core curriculum," which in our experience has proved most essential to the generalist student or practitioner in his use of diagnostic radiology—so that, at least in the radiologic framework, he may begin to feel like the "complete physician."

ISADORE MESCHAN, M.D.

January 9, 1976

Acknowledgments

My acknowledgments for help received for the *Synopsis* are, of course, much the same as those indicated in the three-volume text and need not be repeated here. I continue to be eternally grateful to my wife, Dr. Rachel Farrer-Meschan, who was an "assistant author" of the larger original text and has continued to give unstintingly of her time and critical advice throughout this production as well.

Our secretarial staff, consisting primarily of Mrs. Edna Snow and Mrs. Betty Stimson, continues to be responsible for the typing of each draft of the manuscript, with great perseverance. The original typing of the index was done by Mrs. Edna Snow, Miss Victoria Vogler, and Mrs. Donna Ring. The index was further condensed and edited by the publishers. I continue to be tremendously grateful to the publishers and their several editors for their meticulous care in the reproduction of the illustrations, the editing, and the accuracy of production.

Last, but not least, even though Dr. Anne Osborn is named on the title page as an assistant in the selection of material from the three-volume text, I would once again like to express my indebtedness to her for her great help in selecting specific subjects from a great body of knowledge, so that this book would more closely approximate the "core curriculum" requirements of the medical student, the general practitioner, and the newer generation of young radiologists who might require an "overview" of general radiology.

This book, like other previous volumes, continues to emphasize my deep debt to my associates and to the various members of the Department of Audio-Visual Aids at the Bowman Gray School of Medicine, who were in the first instance responsible for so many of the illustrations. To all of these and many others, I continue to owe gratitude, credit, and acknowledgment. Ultimately, however, I must assume full responsibility for what appears in this text. I can only hope that it will fulfill its purposes.

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January 9, 1976

Contents

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Background Fundamentals for Diagnostic Radiology

SPECIAL PROPERTIES OF X-RAYS WHICH PERTAIN TO DIAGNOSTIC RADIOLOGY

The special properties of x-rays which make them so very useful to diagnostic radiology are: (1) their *ability to penetrate* organic matter; (2) their ability to produce a *photographic effect* on photosensitive film surfaces; and (3) their ability to produce a *phosphorescence* (fluorescence) in certain crystalline materials.

Penetrability of Tissues and Other Substances by X-rays. Tissues and other substances with medical applications may be classified into the categories indicated in Figure 1–2 on the basis of their density and atomic structure. At one end of the spectrum are the *radiolucent* materials, through which the x-rays pass readily; at the other end are the *radiopaque* substances in which the x-rays are absorbed to a considerable degree in their passage so that little radiation escapes.

The x-rays which penetrate an anatomic part may be spoken of as the "remnant rays." These are the rays which ultimately affect the x-ray film or fluorescent screen and are responsible for the gradations of black and white on the image. Thus, in Figure 1–3, x-rays are shown diagrammatically to be traversing the cross-section of a forearm. The gradations of black, gray, and white as shown on the film beneath the forearm are due to the "remnant radiation" after the rays have been absorbed by the interposed tissues such as subcutaneous fat, muscles, and bone.

Unfortunately, in the process of passage through an anatomic structure the x-rays (and the secondary electrons produced within the anatomic part) are scattered in all directions, depending upon the energy of the primary x-ray beam. Such *scattered radiation* causes a loss of detail. Special devices must be interposed between the x-ray source and the film to eliminate the scattered rays from the ultimate image. *Coning devices, stationary and moving grids (Potter-Bucky diaphragm),* which help eliminate such scattered radiation will be described later.

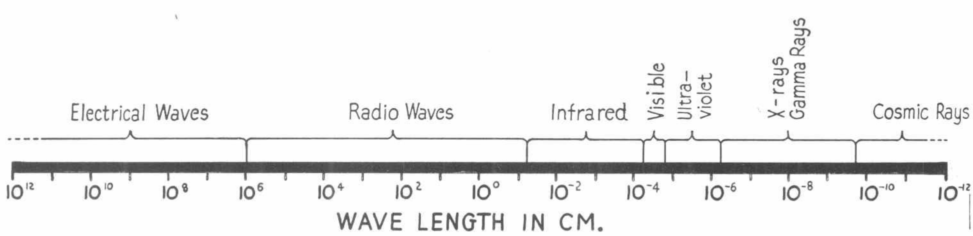


Figure 1–1 Diagram of the electromagnetic spectrum, illustrating the part of this spectrum occupied by x-rays.

VERY RADIOLUCENT	MODERATELY RADIOLUCENT	INTERMEDIATE	MODERATELY RADIOPAQUE	VERY RADIOPAQUE
Gas	Fatty tissue	Connective tissue Muscle tissue Blood Cartilage Epithelium Cholesterol stones Uric acid stones	Bone Calcium salts	Heavy metals

Figure 1–2 Classification of tissues and other substances with medical application in accordance with five general categories of radiopacity and radiolucency.

Photographic Effect of X-rays. Just as visible or ultra-violet rays alter light sensitive photographic emulsion, so do roentgen rays, so that when appropriately "developed," "fixed," and "washed," a permanent image is produced. The film employed for this purpose is ordinarily made with a thicker emulsion, although this is not absolutely necessary. The utilization of intensifying fluorescent screens (to be described below) has largely obviated such "direct radiography," since less x-irradiation is necessary for radiography by intensification techniques. However, when the body part under study (such as an extremity) is not large, when optimum detail is required, and when it is desired to allow no possibility for the interposition of an artefact on the roentgen image, such direct radiography is employed.

Fluorescent Effect of X-rays. When roentgen rays strike certain crystalline materials, a phosphorescence results. The spectrum of light so produced will vary with the crystalline substance—at times, it is largely ultraviolet, at other times, largely visible light. The ultraviolet light has proved to be most advantageous in respect to x-ray film emulsion. Intensifying screens consist mostly of a thin coating of such crystals on a cardboard surface. Their function is to provide a brighter image than would be provided by the direct photographic effect of the x-rays alone.

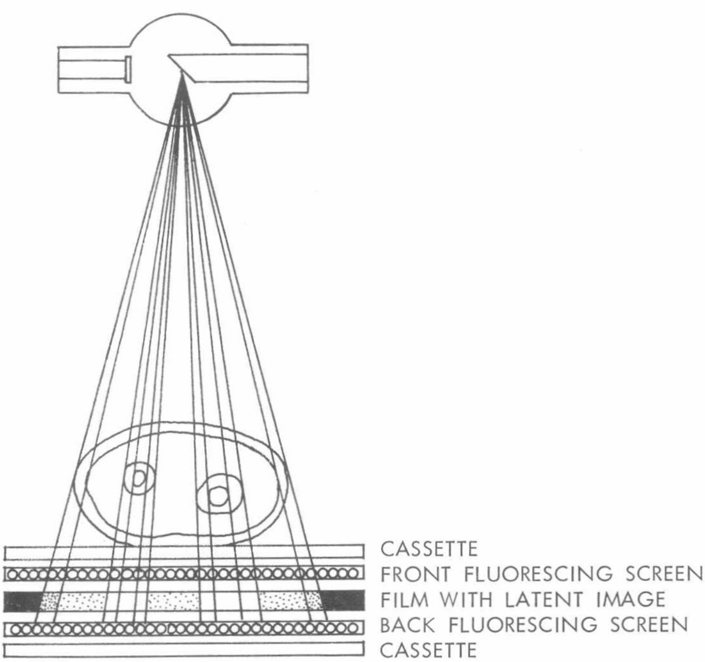


Figure 1–3 Diagram illustrating x-rays from the target of an x-ray tube striking the forearm and passing through a cassette containing film. The remnant radiation passes through the forearm, producing a latent image upon the film.

Contrast Media

A body part may be visualized radiographically on the following bases:

1. The naturally occurring fatty envelope (or fascia)
2. Its naturally occurring gaseous content (lungs; gastrointestinal tract)
3. The naturally occurring mineral salts, such as the calcium salts of bone
4. By abnormally occurring gas, fat, or calcium salts
5. By the introduction of a contrast agent, which may be either *radiolucent* or *radiopaque,* into or around the body part. Such contrast agents should be physiologically inert and harmless.

Commonly Used Radiopaque Contrast Media

BARIUM SULFATE is particularly useful in studies of the gastrointestinal tract. It is inert, is not absorbed, and does not alter the normal physiologic function. At times it is used in colloidal suspension to obtain a particular type of coating of the mucosa, more effective for demonstration of small filling defects.

ORGANIC IODIDES, which are *predominantly excreted by the liver* and concentrated in the biliary tract, include: Telepaque, Priodax, Teridax, and Monophen, which may be given orally; and Cholografin (Biligrafin), which may be given intravenously.

ORGANIC IODIDES, which are *predominantly excreted or secreted selectively by the kidneys,* include: Hypaque (sodium diatrizoate), Renografin (Meglumine diatrizoate), and Iothalamates, such as Conray or Angioconray. These compounds are also widely favored for visualization of blood vessels. In low concentrations, they may be used for visualization of hepatic and biliary radicles by T-tube and operative cholangiography.

ORGANIC IODIDES *in suspension* may be particularly useful in visualization of oviducts (hysterosalpingography) (Sinugrafin) or the urethra (Salpix, Skiodan Acacia, Cystokon, and Thixokon).

IODIZED OILS, *slowly absorbable,* are used in myelography (Pantopaque); or in bronchography (Dionosil Oily).

Radiolucent Contrast Substances are *gases:* air, oxygen, helium, carbon dioxide, nitrous oxide and nitrogen. These are commonly used for visualization of the brain (pneumoencephalograms and ventriculograms), joints (arthrograms), and occasionally the subarachnoid space surrounding the spinal cord (myelograms). Air may also be used in the pleural space, peritoneal cavity, and pericardial space. Carbon dioxide is of particular value since it is well tolerated and very rapidly absorbed.

FUNDAMENTAL GEOMETRY OF IMAGE FORMATION AND INTERPRETATION

Penumbra Formation, Distortion, Magnification. The manner in which an object placed in the path of the x-ray beam is projected depends on five factors: (1) **the size of the light source (effective focal spot size);** (2) **the alignment of the object with respect to the focal spot of the x-ray tube and the screen or films;** (3) **the distance of the object from the focal spot;** (4) **the distance of the object from the screen or film;** and (5) **the plane of the object with respect to the screen or film.**

When an image is projected from a pinpoint light source or focal spot, its borders are sharp. However, if the light source is a larger surface, the image is ill-defined at its periphery owing to "penumbra" formation (Figure 1–5).

In order to reduce the penumbra as much as possible the following measures must be taken: (1) the focal spot must be as small as possible; (2) the object-to-film distance must be as short as possible; (3) the object-to-focal-spot distance must be as distant as is practicable (Figure 1–5 B and C).

When the object is not centrally placed with respect to the central ray its image will be distorted, sometimes considerably (Figure 1–4). At times this distortion is unavoidable if one is to visualize an anatomic part (Figure 1–7), and in some of the radiographic positions this distortion brings into view a part which otherwise would be hidden. The phenomenon of projection may therefore be utilized to good advantage.

The problems of magnification must also be taken into consideration. Teleroentgenograms are "long distance radiographs," which diminish magnification. A minimum target-to-film distance of 6 feet is utilized for this purpose and even under these circumstances magnification of 10 to 15 per cent may be obtained for structures at a considerable distance from the film.

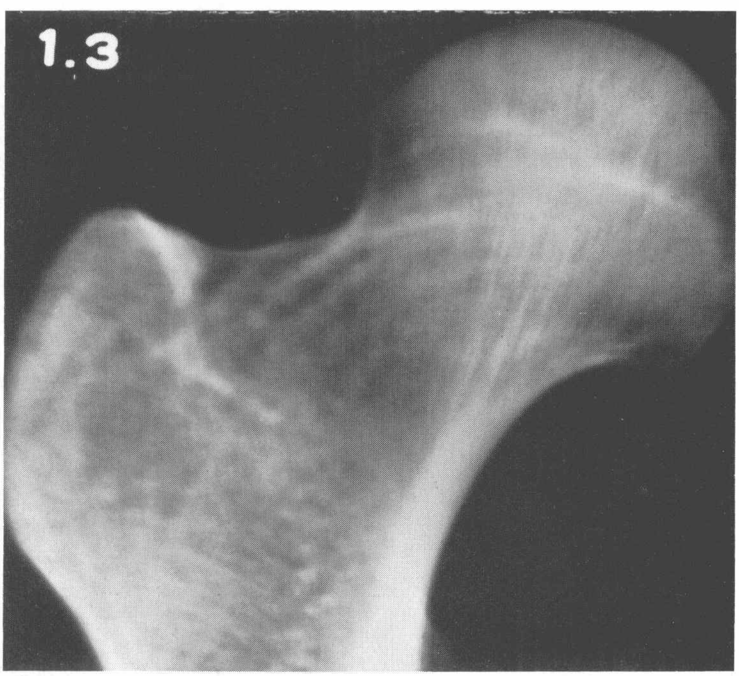
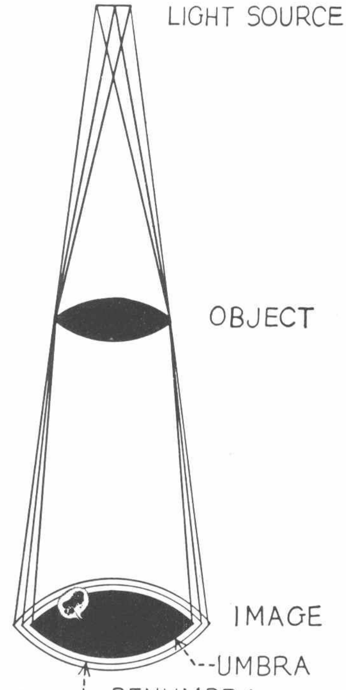


Figure 1–4 Radiograph showing blurring of an anatomic part caused by faulty relationship of the x-ray tube to the part being radiographed. In this instance the object-to-film distance was increased to 30 inches, but even though a relatively small focal spot was used and the other factors were correct, there is a significant blurring of the trabecular pattern of the head and neck of this femur. Roughly, a times 3 magnification was obtained, as the focal-film distance was 40 inches.

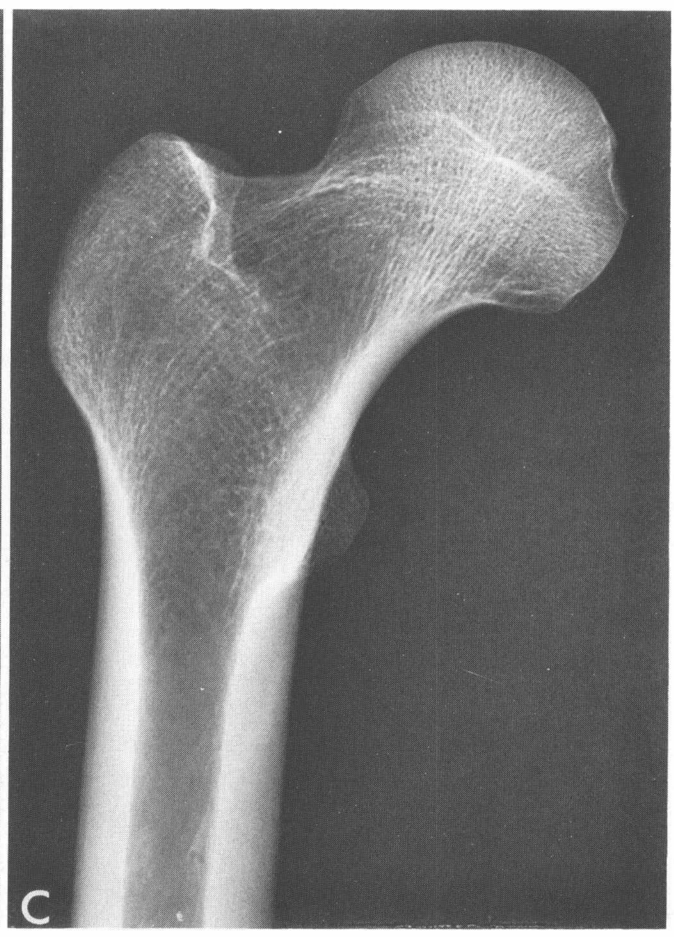


A

Figure 1–5 *A*. The smaller the focal spot the sharper the image. The illustration shows penumbra and umbra formation from a "surface" light source rather than a "point" source. Most x-ray targets are surface sources even though they are a fraction of a millimeter in size. A 0.12 mm. focal spot, if available, is useful in some magnification procedures, since it has virtually no penumbra. Most x-ray images are made with effective focal spot sizes of 0.6 mm. to 2 mm. *B*. Radiograph of a femur obtained at a focal-film distance of 72 inches and contact of the femur with the film (hence, object-to-film distance is zero), with a 1.3 mm. target size. Note that at this distance, with close contact of the object to the film, the trabecular pattern as visualized is excellent. (Courtesy of C. Ritchie, Winston-Salem, N.C.) *C*. Radiograph of the same femur again taken at 72-inch focal-film distance and a 0.3 mm. focal spot size. Notice that the trabecular pattern also appears distinct. At this long focal-film distance with good contact of the object with the film no particular gain is obtained at 0.3 mm. focal spot size.

Illustration continued on the following page

B



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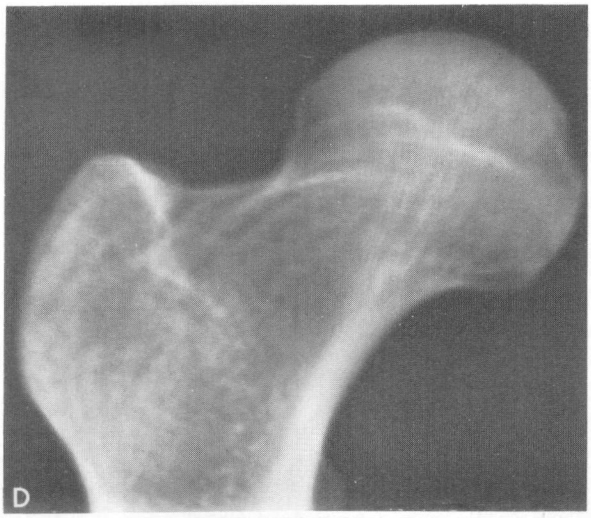


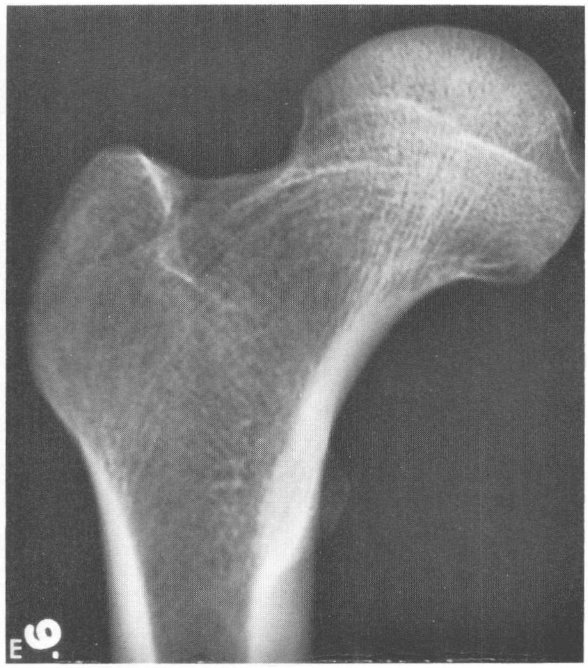
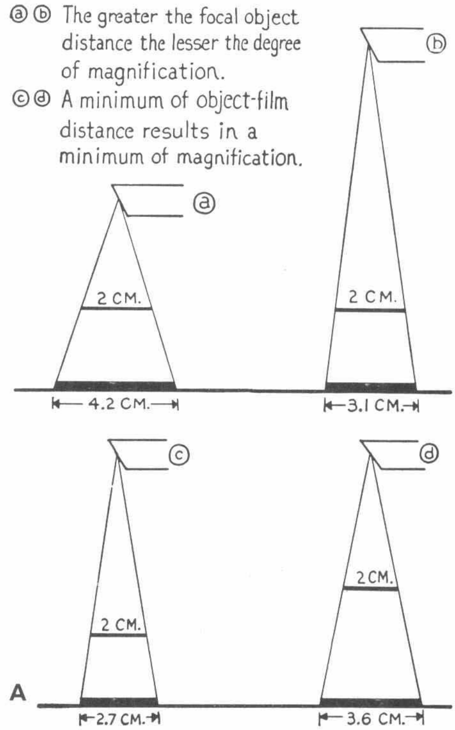


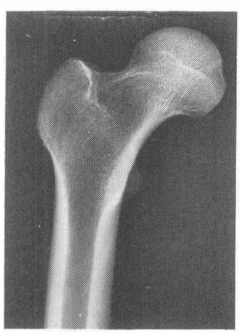
Figure 1–5 (*Continued*) *D*. Radiograph of same femur taken at 72-inch focal-film distance with an object-film distance of 48 inches and a target size of 1.3 mm. Note the marked blurring that results. *E*. Here the same factors were employed as in *D*, except that the focal spot size was 0.6 mm. Reasonably good definition of the trabecular pattern of the femur results, even though the object-to-film distance was 48 inches as before. *F*. The focal spot size here is 0.3 mm., with all other factors the same. This is the optimum target size for detail when such long object-film distances are necessary. The magnification in *D*, *E*, and *F* is approximately times 3.



A

Figure 1–6 *A*. Effect of focal-object distance and object-film distance on magnification.

B and *C*. Radiographs of a femur showing the magnification that occurs when an anatomic part is placed at some distance from the film in relation to the total distance of the target to the film. In *B*, the object-to-film distance was 0 (good contact), whereas in *C* it was 30 inches. In both instances a very small focal spot size (0.3 mm.) was employed so that good detail was obtained even at a magnification of times 3 in *C*. (Courtesy of C. Ritchie, Winston-Salem, N.C.)



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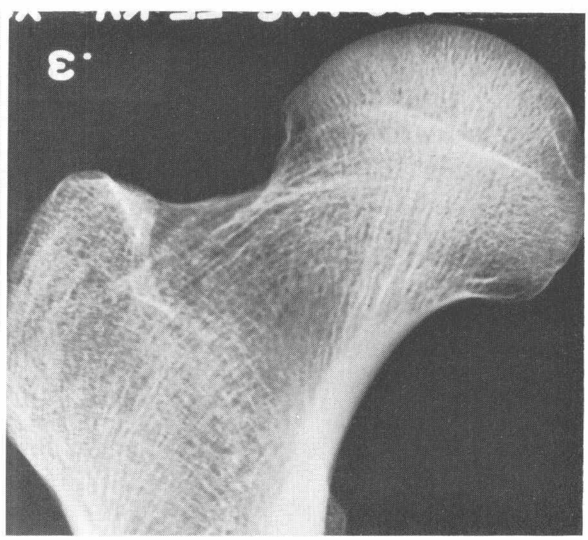

C