XERORADIOGRAPHY AS A TECHNIQUE FOR DIAGNOSING OSTEONECROSIS

CHARLES J. FAGAN
EDWARD L. BECKMAN

Xeroradiography is a relatively unfamiliar but not completely new method of radiological investigation. One may define xeroradiography as a technique in which photoconductors and electrostatic charges are used to record X-ray images. Selenium, although normally a good insulator, becomes a charge conductor under the action of light or ionizing radiation. Whereas a conventional X-ray plate consists of a film in a cassette, a xeroradiographic plate consists of a positively charged metal surface coated with selenium. When this plate is exposed by use of conventional X-ray equipment, the roentgen rays cause a run-off, proportional to their intensity, of the charge area on the plate that they strike. The charge plate is dusted with negatively charged powder, producing an image similar to that seen on a standard roentgenogram. The image can be preserved by transferring it to paper or by photographing it (Wolfe, 1969).

Some of the advantages reported for xeroradiography over conventional radiography are these:

1. A standard radiographic film in a cardboard holder will delineate a wire mesh of only 100 lines per inch, whereas a xeroradiograph will record a mesh of 1200 lines/inch.
2. An electrostatic phenomenon, termed the

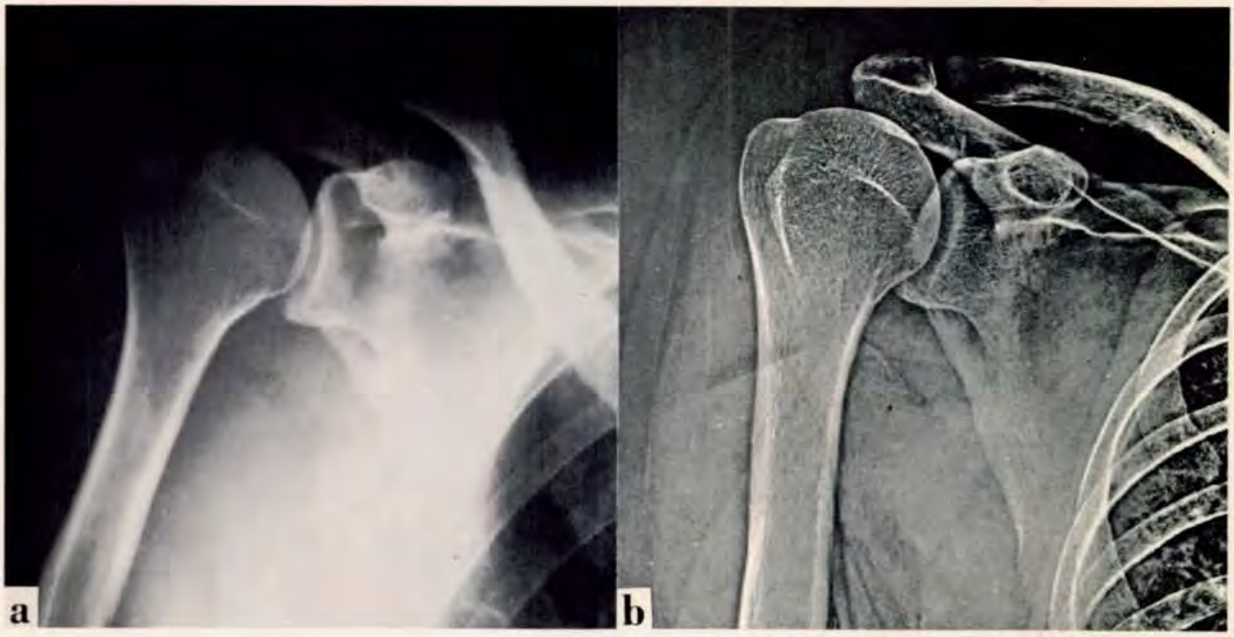

FIG. 1. Roentgenographic bone survey of a Gulf of Mexico diver, which proved negative for osteonecrosis. (*a*) Frontal projection on conventional film of L shoulder, compared with (*b*) xeroradiogram.

edge enhancement effect, accentuates borders or areas of different densities. Specifically, differences in density within a structure — *e.g.*, a fracture line in bone, the edge of a dominant mass density in the breast, or an opaque foreign body in soft tissues — are all readily recorded on the xeroradiogram (Wolfe, 1968; Woesner and Sanders, 1972).

3. Xeroradiography permits a wide range of exposure factors. For example, a range of 20 kv is possible without deterioration of the image quality. Thus precision in setting up the exposure factors is not as critical in xeroradiography as it is in conventional radiography.
4. A single roentgenogram does provide, to be sure, a wide range of bone and soft-tissue detail. By comparison, a single lateral xeroradiogram of the neck (for example) vividly demonstrates soft-tissue structures, the bony parts, and structures outlined by air. If one uses conventional radiography to obtain the same information, at least two exposures — one for soft-tissue detail and one for bony detail — would be necessary. Furthermore, the xeroradiograph is of value in some cases in eliminating the need for tomographic sections, which impart a relatively higher radiation dose to the patient than xeroradiography does.
5. The xeroradiogram is processed in a lighted room, eliminating the need for the darkroom equipment of conventional radiography.

The main disadvantages of xeroradiography are these: First, the radiation required to develop a xeroradiographic image is considerably greater

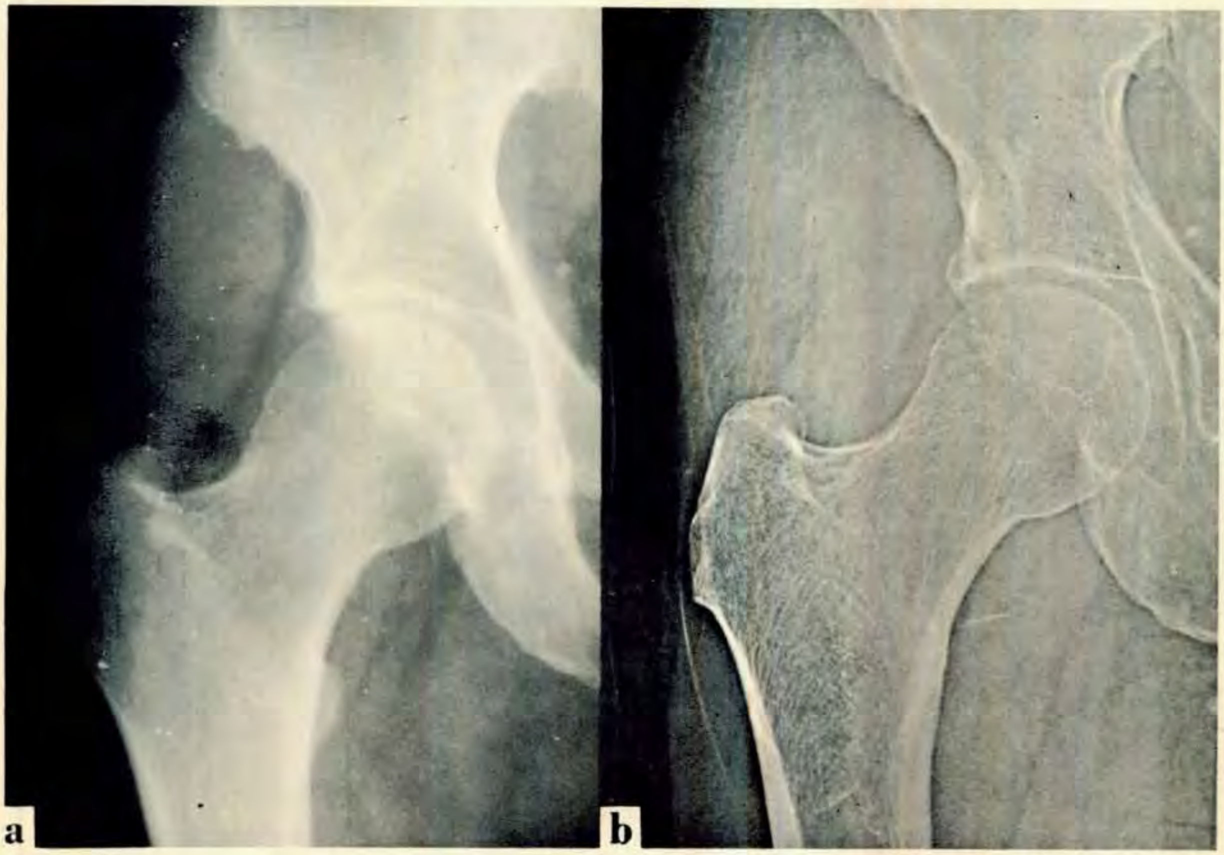

FIG. 2. Same diver as in Fig. 1. Comparison of (*a*) frontal roentgenogram of R hip with (*b*) xeroradiogram of R hip.

than that required in roentgenography with film-intensifying screens. Accordingly, an exposure of the shoulder results in a fivefold increase in radiation dosage to the patient; of the hip area, a sevenfold increase; and of the knee area, a twofold increase. Second, there are reports of low contrast and loss of fine detail in skeletal work. There is not universal agreement, however, that these objections are entirely valid (Wolfe, 1969).

In an attempt to judge the ultimate value of xeroradiography as a diagnostic tool in the detection of osteonecrosis, a limited number (seven) of xeroradiographic studies was made and then compared with similar projections made with conventional roentgenographic techniques.

TECHNIQUE

The present xeroradiographic osteonecrosis survey consisted of the same projections typically made in a roentgenographic survey — specifically, frontal projections of the shoulders and hips, and frontal and lateral projections of both knees (Martel and Sitterley, 1969). In some instances, frogleg projections of the hips were made. Exposure factors of the shoulders were in the 70-85 KVP, 20-40 MAS range; in the hips, 85-100 KVP, 100-150 MAS range; and in the knees, 75-90 KVP, 10-30 MAS range. The xeroradiograms were then compared with existing roentgenograms made of the same areas.

FIG. 3. Same diver as in Fig. 1. Frontal projection of L knee on (*a*) conventional roentgenogram and on (*b*) xeroradiogram.

FIG. 4. Same diver as in Fig. 1. Lateral projection of L knee on (*a*) conventional roentgenogram compared with (*b*) xeroradiogram.

DISCUSSION

A comparison is made in Fig. 1 through 4 of roentgenograms and xeroradiograms of subjects in whom no osteonecrosis was diagnosed. The excellent detail of soft-tissue and skeletal parts in the xeroradiogram initially generated enthusiasm about the technique. When xeroradiograms and roentgenograms were compared in cases of a positive diagnosis of osteonecrosis (Fig. 5 and 6), however, detail in the actual area of disease on the former was disappointing.

In yet another case (Fig. 7), the subtle circular cystic formation in the right humeral shaft, which is evident on the roentgenogram, is seen on neither the negative nor positive xeroradiograms. However, the general bony detail depicted on the positive-image xeroradiogram is superior to the detail on the negative-image

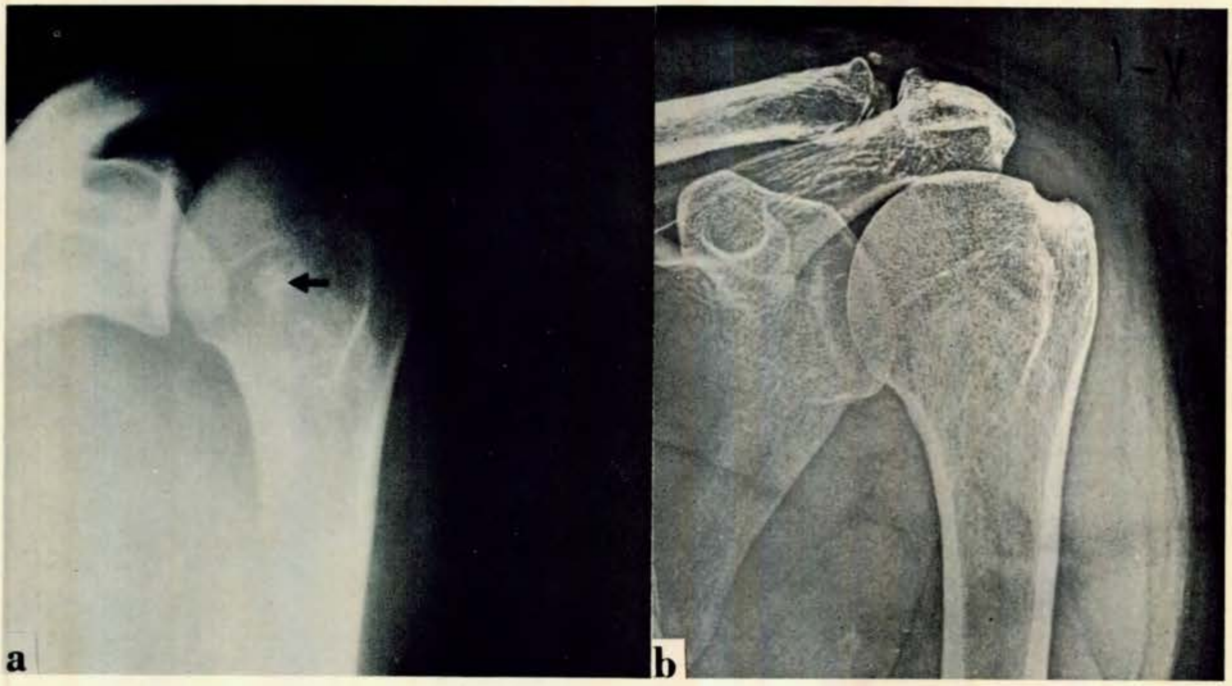

FIG. 5. Bone survey of a Gulf of Mexico diver, which proved positive for osteonecrosis. (*a*) Conventional roentgenogram of L shoulder (osteonecrotic area marked with arrow) required less exposure of subject and demonstrates lesions as well, if not better, than (*b*) the xeroradiogram.

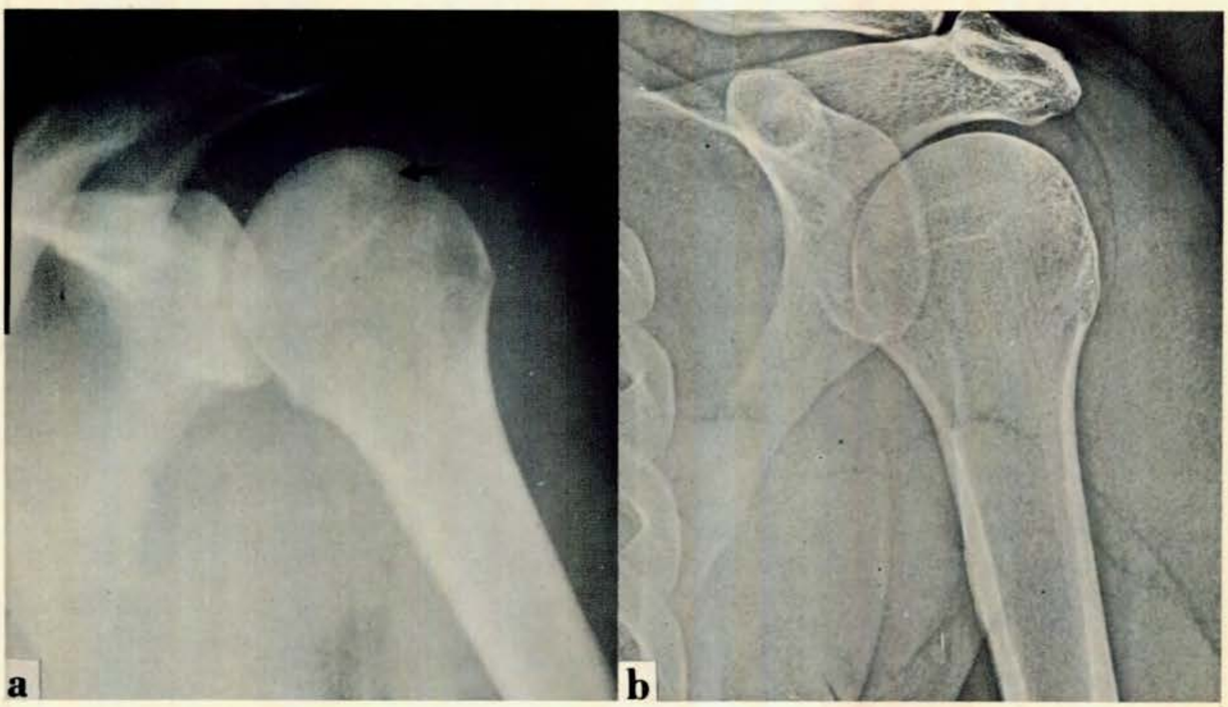

FIG. 6. (*a*) Subtle area of osteonecrosis (arrow) in juxta-articular area of R humerus of diver, as demonstrated roentgenographically. (*b*) Lesion is not evident on xeroradiogram.

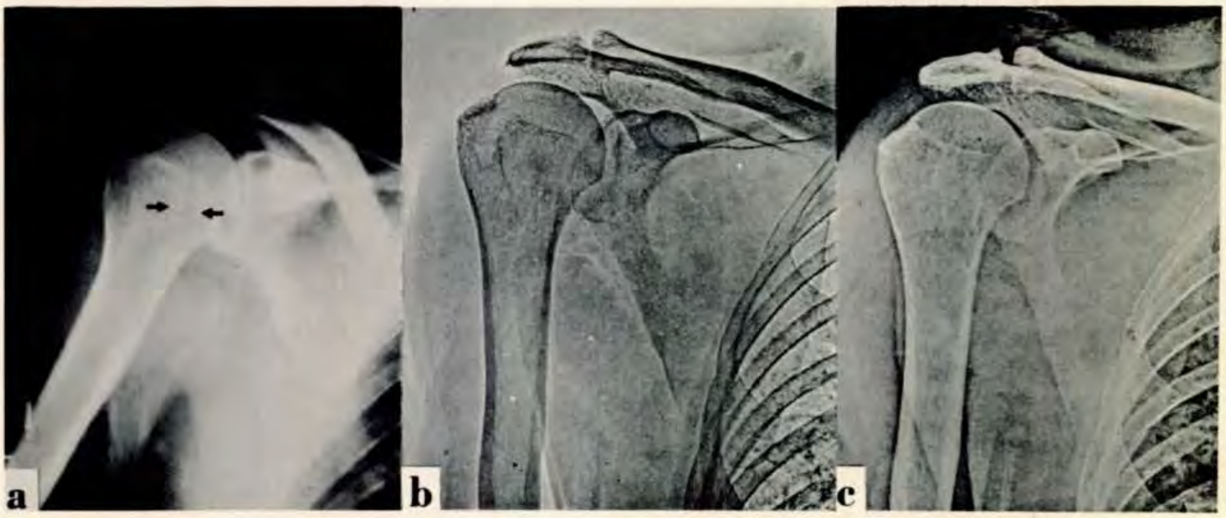

FIG. 7. (*a*) Conventional roentgenogram demonstrates subtle circular cystic formation in R humeral head of diver. Finding is not evident on either (*b*) positive or (*c*) negative xeroradiogram. Note, however, better bone detail on positive xeroradiogram in comparison with negative one.

xeroradiogram. As a result, if xeroradiography is to be used for bone work, such as in an osteonecrosis survey, it appears that positive imaging is superior to negative imaging.

CONCLUSION

Although the number is small, these comparisons of conventional radiography and xeroradiography suggest that the latter is not sufficiently useful as a diagnostic tool to justify the greater radiation exposure inherent in its use. This conclusion should, perhaps, be regarded as tentative, until further evidence supporting the usefulness of xeroradiography in connection with the diagnosis of osteonecrosis is accumulated.

REFERENCES

Martel, W., and Sitterley, B. H. (1969). Roentgenologic manifestations of osteonecrosis. Amer. J. Roentgenol., Radium Therapy Nucl. Med. 106 (3), 509-522.

Woesner, M. E., and Sanders, I. (1972). Xeroradiography: A significant modality in the detection of nonmetallic foreign bodies in soft tissues. Amer. J. Roentgenol., Radium Therapy Nucl. Med. 115, 636-640.

Wolfe, J. N. (1968). Xeroradiography of the breast. Radiology 91 (2), 231-239.

Wolfe, J. N. (1969). Xeroradiography of the bones, joints and soft tissues. Radiology 93 (3), 583-587.