DENTAL XERORADIOGRAPHY AS AN ADJUNCT IN THE EVALUATION OF ORAL CANCER: A PRELIMINARY REPORT

BARTON M. GRATT, D.D.S.,
EDWARD A. SICKLES, M.D.
and
SOL SILVERMAN, JR., D.D.S., M.S.
San Francisco, Calif.

Division of General Dentistry, Schools of Dentistry and Medicine, University of California at San Francisco

Reprinted from
ORAL SURGERY, ORAL MEDICINE, ORAL PATHOLOGY
St. Louis

Vol. 49, No. 4, pp. 303-308, April, 1980

Editor:
JAMES W. LITTLE, D.M.D., M.S.D.
Department of Oral Diagnosis and Oral Medicine
University of Kentucky
Lexington, Kentucky 40506

Dental xeroradiography as an adjunct in the evaluation of oral cancer: A preliminary report

Barton M. Gratt, D.D.S., Edward A. Sickles, M.D.,** and Sol Silverman, Jr., D.D.S., M.S.,*** San Francisco, Calif.*

DIVISION OF GENERAL DENTISTRY, SCHOOLS OF DENTISTRY AND MEDICINE, UNIVERSITY OF CALIFORNIA AT SAN FRANCISCO

This pilot study of an experimental dental xeroradiography imaging system involved twelve oral cancer clinic patients. Xeroradiographs were compared with conventional intraoral film radiographs, taken with similar x-ray projections. The new dental xeroradiographic system was judged superior for the imaging of both osseous and soft-tissue structures. Especially significant was the new imaging system's ability to portray early bone erosion not detectable with the conventional intraoral film technique. These results point to the need for controlled clinical evaluations of dental xeroradiography, in order to assess the full potential of this rapid, low-radiation imaging system in the evaluation of oral cancer.

Xeroradiography is a diagnostic x-ray imaging technique that uses the xeroradiographic copying process to record x-ray images. Xeroradiographic images have two major advantages over conventional film images: (1) They demonstrate a broader exposure latitude, permitting visualization in a single image of the full range of oral tissue densities, from soft tissues to metallic restorations.[1, 2] (2) They have a property called *edge enhancement*, by which fine structural details and subtle areas of density difference are made more visible.[3, 4]

Over the past 10 years xeroradiographs have been produced with the Xerox 125 Medical System,† with principal application to mammography[5] but also for the imaging of other body parts, such as the larynx,[6] respiratory tract,[7] and paraosseous soft tissues.[8] The Xerox 125 medical system has also been adapted to extraoral dental use, including cephalometrics,[9–11] temporomandibular joint radiography,[12] sialography,[13, 14] and panoramic radiography.[15]

Recently, a prototype xeroradiographic imaging system was developed specifically for *intraoral* use. Compared to conventional (high detail, D speed) intraoral film, the new dental xeroradiography imaging system demonstrates superior resolution, a broader range of exposure latitude, edge enhancement, and improved imaging of teeth, bone, and soft tissues.[16, 17] In addition, early clinical trials using the prototype unit demonstrated that the new system is superior for imaging of dental structures necessary for successful periodontal and endodontic therapy, and at one third the radiation dose of conventional intraoral film techniques.[18, 19]

In this pilot clinical study we investigated the utility of the prototype dental xeroradiography system for im-

This study was supported in part by funds from Biomedical Research Support Grant RR-05305-17 (78439-29681-3).

*Assistant Professor, Oral Radiology, Division of General Dentistry.
**Chief, Mammography Section, Department of Radiology.
***Professor, Chairman of the Department of Oral Medicine/Hospital Dentistry.

†Xerox Medical Systems, Pasadena, Calif.

0030-4220/80/040303+06$00.60/0

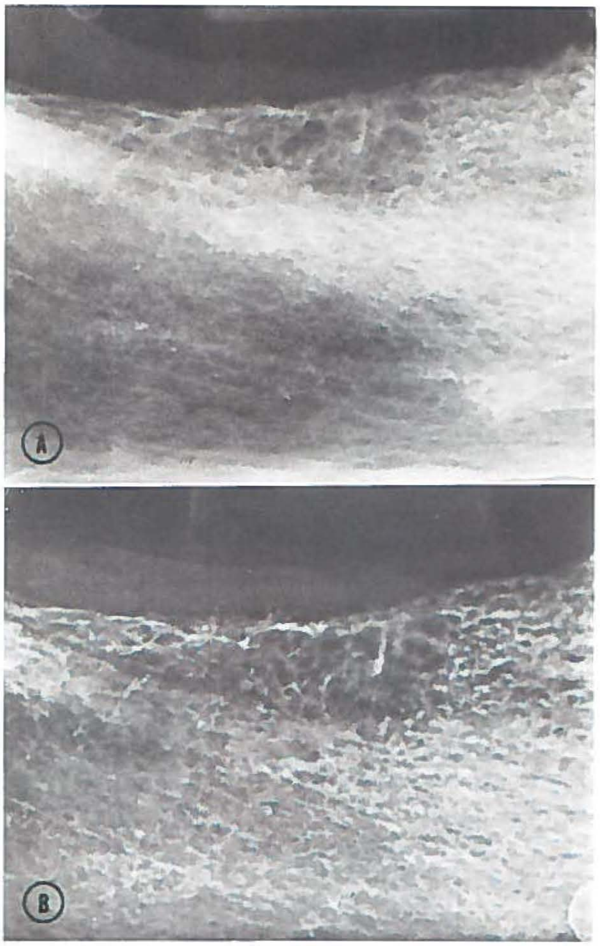

Fig. 1. A, Conventional intraoral periapical (film) radiograph of the posterior mandibular molar region demonstrating alveolar crestal bone and medullary bone with its trabecular pattern. **B,** Similarly projected dental xeroradiograph demonstrating finer bony details and greater numbers of bone trabeculae.

Table I. Comparison of dental xeroradiography and conventional radiography for the imaging of osseous and soft-tissue structures in oral cancer diagnosis

Structure	*Conventional radiography*	*Dental xeroradiography*
Osseous tissues		
Cortical bone	++	+++
Medullary bone	++	+++
Alveolar crestal bone	++	+++
Lamina dura	++	+++
Trabecular pattern	++	+++
Exophytic bony changes	+	+++
Bony erosions		
Early bone loss	0	++
Moderate bone loss	++	+++
Advanced bone loss	+++	+++
Soft tissues		
Shape	+	++
Size	+	++
Outline	+	++
Density	0	++
Texture	0	++
Thickness	0	++
Calcifications	0	++

Scale: Optimal visualization, +++; adequate, ++; poor, but diagnostic, +; unacceptably poor, 0.

aging oral cancers, with particular attention to subtle radiographic features that may indicate invasion of bony structures.

MATERIALS AND METHODS

The study population consisted of twelve volunteer patients who were seen in the Oral Medicine/Oral Cancer Clinic of the University of California Dental School in San Francisco. These patients either had a previous history of oral cancer, had a suspected cancerous or precancerous lesion, or had completed radiation and/or surgical treatment for known oral cancer. Informed consent was obtained, and intraoral xeroradiographs were taken of a variety of regions of diagnostic interest. As often as possible, conventional film radiographs were obtained for comparison, using similar radiographic projections. We attempted to image the tissues of the floor of the mouth, the soft tissues of the lateral border of the tongue, and the gingival soft tissues over alveolar bone. Images were carefully evaluated for changes in dimension, contour, and density of the soft tissues, as well as for the presence of calcifications. In addition, fine bony detail was evaluated on both dental xeroradiographs and conventional film radiographs, with particular attention to small erosions of bone and to subtle changes of cortical, medullary, alveolar, and trabecular bone that might herald the presence of oral cancer. Resultant radiographs and xeroradiographs were examined, and an appraisal of their diagnostic quality was made, based on the appearance and clarity of radiographic features we judged to be potentially useful in radiogrpahic detection of oral cancer. These fell into three major categories: (1) osseous structural detail, (2) bone erosions, and (3) soft-tissue changes. For each set of paired images (dental xeroradiograph versus conventional film radiograph), these items were classified as either optimal for diagnostic evaluation(+++), adequate for diagnosis (++), poor but diagnostic (+), or unacceptably poor (0). All judgments were made independently by a dental (B.M.G.) and a medical (E.A.S.) radiologist, both expert in conventional film and xeroradiographic interpre-

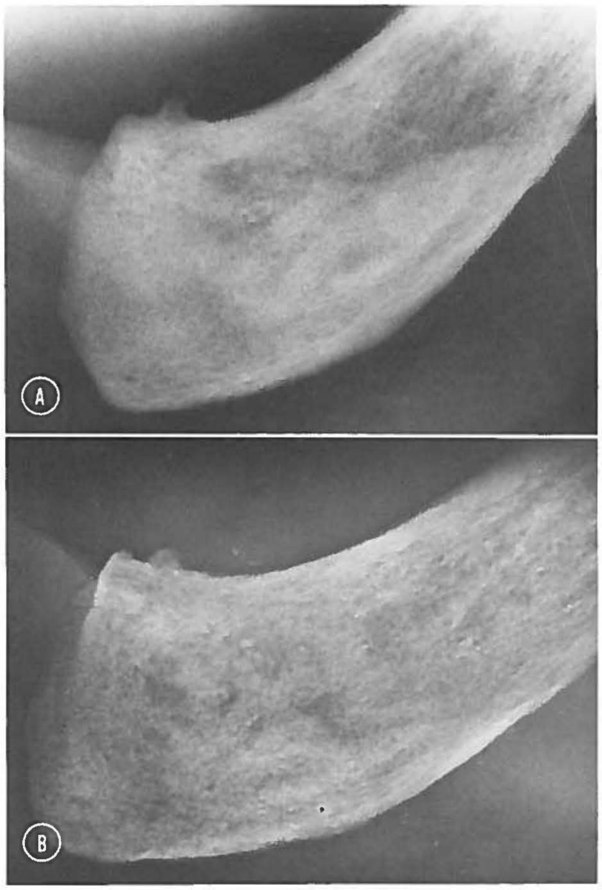

Fig. 2. A, Conventional occlusal radiograph of a hemisectioned mandible treated for an osteosarcoma. No recurrance was observed. **B,** Similarly projected dental xeroradiograph demonstrating the improved imaging of fine osseous structures, bony edges, and trabecular pattern. Again, no recurrence was observed.

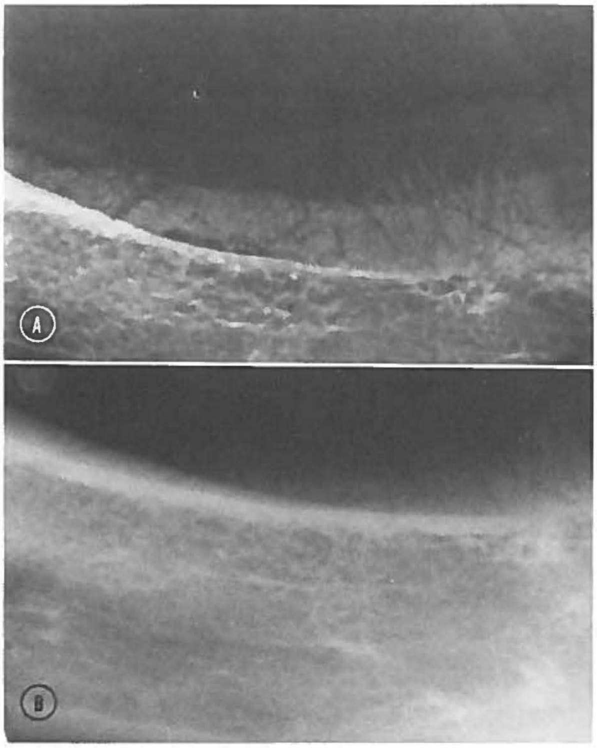

Fig. 3. A, Periapical dental xeroradiograph of the posterior mandibular molar region 2 weeks after radiation therapy for squamous cell carcinoma of the oral pharynx. Note the fine exophytic spicules of bone and the subtle soft-tissue calcifications in the upper right region of the xeroradiograph. **B,** Similarly projected conventional film radiograph, poorly demonstrating the exophytic bony changes and failing to demonstrate any soft-tissue calcification.

tation. This method, although subjective, has been used successfully in other investigations to evaluate diagnostic radiographic image quality.[16, 18]

X-ray equipment

A conventional General Electric 100* dental x-ray unit (nominal focal spot size, 1.0 mm.; total filtration of 2.5 mm. aluminum; half-value layer, 2.8 mm. aluminum equivalent) was used to produce both the conventional film radiographs and the xeroradiographs. Radiographic projections were taken by the paralleling technique, with at least a 16 inch (41 cm.) target-film distance, a beam diameter of 2¾ inches (7 cm.), a 60 to 100 kVp, and 10 mA. Exposure times were varied (depending upon the specific region of dental anatomy) from ½ second to 1 second (30 to 60 impulses) for conventional film radiographs and from 1/6 second to ½ second (10 to 30 impulses) for dental xeroradiography.

Film images

Conventional film images were recorded on intraoral dental film (Kodak D speed occlusal and periapical film, DF-45, DF-55, and DF-57,* paper-wrapped, double film packets). Films were manually developed according to manufacturer's specifications, using Kodak chemistry at 68° F.

Dental xeroradiographs

For intraoral dental xeroradiographs, the prototype dental xeroradiography image-processing system† was used. This employs selenium-coated photoreceptor plates housed in small light-tight cassettes especially designed for intraoral use. The xeroradiographic pro-

*General Electric Company, Milwaukee, Wis.

*Eastman Kodak Company, Rochester, N. Y.
†Xerox Medical Systems, Pasadena, Calif.

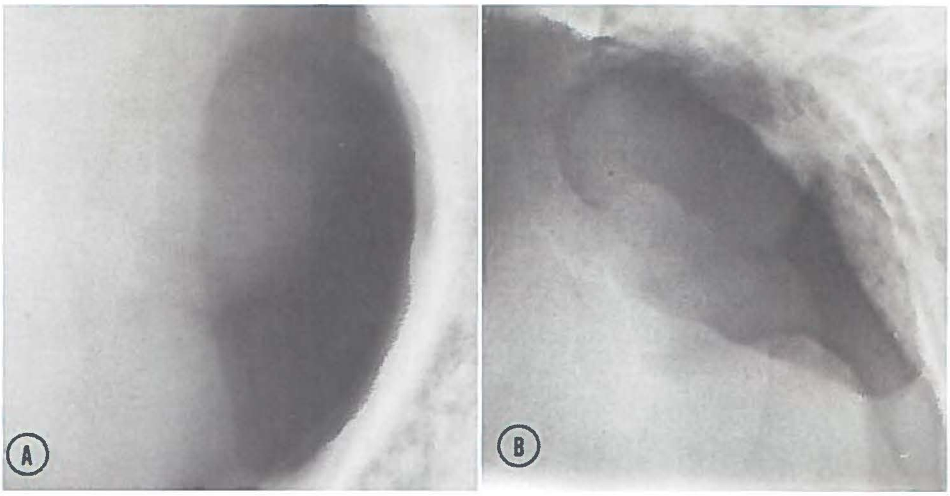

Fig. 4. A, A mandibular occlusal (film) radiograph of a postirradiation patient with osteoradionecrosis and a large soft-tissue defect of the floor of the mouth. **B,** A similarly projected dental xeroradiograph of the same soft-tissue defect demonstrating outlines, shape, size, density, texture, and thickness of soft tissues not evident when film radiography is used.

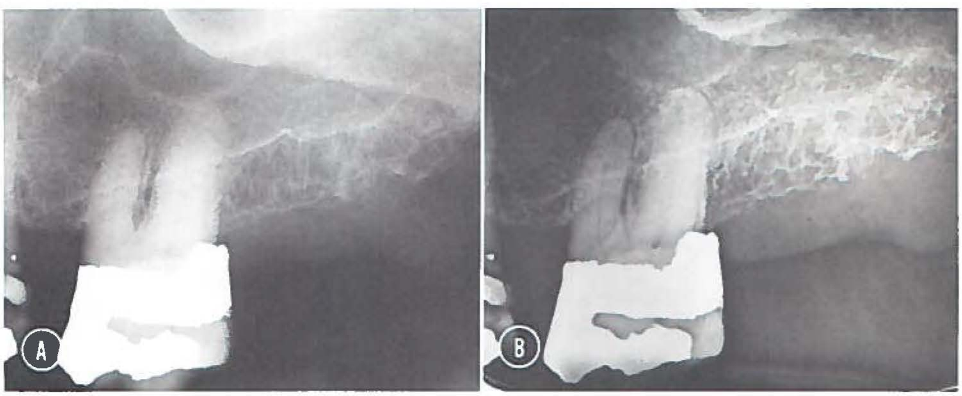

Fig. 5. A, Conventional (film) radiograph of the maxillary molar periapical region demonstrating adequate bone imaging and poor soft-tissue detail. **B,** Similarly projected dental xeroradiography demonstrating superior images of bony structures (lamina dura, alveolar crestal bone, floor of maxillary sinus, and trabecular pattern) and superior imaging of gingival soft-tissue structures (height, contour, and density). The superior bony imaging with dental xeroradiography may be an additional aid in determining bone involvement from oral cancer.

cessor charges each photoreceptor plate and inserts it into a cassette, which is then placed in a disposable plastic bag. This is positioned in the patient's mouth, a radiograph is taken, and the cassette is then reinserted into the processing unit, where the latent image on the photoreceptor plate is developed. Using black liquid toner for maximum image contrast, the system produces a permanent hard-copy xeroradiogrpahic image in 20 seconds. The used photoreceptor plate is then automatically reconditioned and stored for future use.

RESULTS

The findings of the comparative clinical analysis of xeroradiographs and conventional film radiographs are presented in Table I. For all categories of diagnostic evaluation, the information provided by dental xeroradiography was either equal to or greater than that provided by conventional radiographs.

Osseous structures

Xeroradiographic images were judged superior to conventional film images in the portrayal of fine bony structural detail. This was especially true for bone trabeculae and for exophytic bony changes (Figs. 1 to 3).

Bone erosion

Erosion of bone was also seen more clearly with dental xeroradiography. Dental xeroradiographs were able to image early bone loss due to invasive squamous cell carcinoma (floor of the mouth) in cases in which the conventional radiographs were interpreted as normal.

Soft-tissue structures

Soft-tissue outlines were not clearly defined on conventional film radiographs, but these same structures demonstrated well-defined outlines on xeroradiographs, permitting confident evaluation of soft-tissue height and contour (Fig. 4). There was also greater over-all soft-tissue detail on the dental xeroradiographs, enabling us to evaluate soft-tissue density, texture, and contents (Fig. 5). In addition, several oral soft-tissue calcifications which were not seen with conventional film radiography were noted on the dental xeroradiographs (Fig. 3).

DISCUSSION

Dental xeroradiography was judged to be superior to conventional intraoral film techniques in this pilot study involving twelve pre- and posttreatment oral cancer patients. Dental xeroradiographs demonstrated superior visualization of bone detail, thereby potentially allowing for more accurate estimates of the extent of bone involvement from oral cancer. Xeroradiographic visualization of early bone erosion may well prove to be a significant advance in the presurgical evaluation of the patient with suspected or known oral cancer, since the determination of whether a cancerous lesion has invaded bone or whether recurrence is present can result in substantial changes in the extent and timing of treatment planning.

Soft-tissue imaging was also found to be superior with dental xeroradiography; this, too, may prove useful as our knowledge of soft-tissue imaging increases. While we are not now aware of soft-tissue radiographic features of carcinoma, xeroradiography provides us with the means for detecting and characterizing any such changes.

An additional advantage of dental xeroradiography is its low radiation dose; it requires only one half to one fourth (average, one third) of the radiation exposure of conventional intraoral film radiography.[16, 17] This reduction in radiation exposure is beneficial to both patients and dental office personnel. Should xeroradiography prove to have more extensive clinical applications than conventional film imaging, serial radiographic evaluations of postsurgical and irradiated areas can be undertaken with a decreased risk of excessive radiation exposure.

Finally, the newly designed dental xeroradiographic equipment demonstrated several major convenience features over conventional film techniques. The system produces permanent dry images in only 20 seconds, without the need for wet chemicals, fixed plumbing installation, or a darkroom. Xeroradiography equipment is compact, light weight, and portable. In addition, the prototype unit that we tested proved very reliable, producing more than 1,200 xeroradiographs without any mechanical breakdown.

In summary, dental xeroradiography appears to be a convenient, low-dose, high-resolution imaging system that can visualize (1) greater bony detail, (2) more soft-tissue detail, and (3) more subtle regions of bone erosion than conventional film radiography. This new imaging system appears to offer considerable promise in evaluating the true extent of oral cancer, thereby providing valuable preoperative information for treatment planning. Additional study is needed to determine the full potential of dental xeroradiography in the evaluation and treatment of oral cancer.

The authors are grateful to Mr. Lothar S. Jeromin and Mr. Glenn F. Geddes of the Xerox Corporation, Pasadena, California, for operation of the prototype dental xeroradiographic equipment.

REFERENCES

1. Gratt, B. M., White, S. C., Sickles, E. A., and Jeromin, L. S.: Imaging Properties of Intraoral Dental Xeroradiography, J. Am. Dent. Assoc. **99:** 805-809, 1979.
2. Gratt, B. M., Sickles, E. A., and Parks, C. R.: Xeroradiography of Dental Structures. II. Image Analysis, ORAL SURG. **45:** 156-165, 1978.
3. Gratt, B. M., Sickles, E. A., and Parks, C. R.: Xeroradiography of Dental Structures. I. Preliminary Investigation, ORAL SURG. **44:** 148-152, 1977.
4. Jeromin, L. S., Geddes, G. F., White, S. C., and Gratt, B. M.: Xeroradiography for Intraoral Dental Radiology: A Process Description, ORAL SURG. **49:** 178-183, 1980.
5. Wolfe, J. N.: Xeroradiography of the Breast, Springfield, Ill., 1972, Charles C Thomas Publisher.
6. Doust, B. D., and Ting, Y. M.: Xeroradiography of the Larynx, Radiology **110:** 725-727, 1974.
7. Doust, B. D., Ting, Y. M., and Chuang, V. P.: Detection of Aspirated Foreign Bodies With Xeroradiography, Radiology **111:** 725-727, 1974.
8. Otto, R. C., Pouliadis, G. P., and Kumpe, D. A.: The Evaluation of Pathologic Alterations of Juxtaosseous Soft Tissue by Xeroradiography, Radiology **120:** 297-302, 1976.
9. Davis, R., Binnie, W. H., Reed, R. T., and Stacey, A. J.: The Role of Xeroradiography in Cephalometric Radiology. J. Dent. **5:** 32-38, 1977.
10. Hurst, R. V. V., Schwaniger, B., Shaye, R., and Chadha, J. M.: Landmark Identification Accuracy in Xeroradiographic Cephalometry, Am. J. Orthod. **73:** 568-574, 1978.
11. Johnson, Nicholas, A.: Xeroradiography for Cephalometric Analysis, Am.J. Orthod. **69:** 524-526, 1976.
12. Xerox Corp.: Xeroradiography for Temporomandibular Joint, Medical Application Bulletin 115, December, 1973.
13. Ferguson, M. M., Davison, M., Evans, A., and Mason, W. N.: Application of Xeroradiography in Sialography, Int. J. Oral Surg. **5:** 176-179, 1976.
14. Glassman, L. M., O'Hara, A. E., and Cregar, D.: Xerosialography, Arch. Otolaryngol. **100:** 341-343, 1974.
15. Snyder, M. B., et al.: The Advantages of Xeroradiography for

Panoramic Examination of the Jaws and Teeth, J. Periodontol. **48:** 467-472, 1977.
16. Gratt, B. M.: Xeroradiography of Dental Structures. III. Pilot Clinical Studies, ORAL SURG. **48:** 276-280, 1979.
17. White, S. C., and Gratt, B. M.: Intraoral Dental Xeroradiography: Clinical Trials, J. Am. Dent. Assoc. **99:** 810-816, 1980.
18. Gratt, B. M., Sickles, E. A., and Armitage, G. C.: Use of Dental Xeroradiographs in Periodontics: Comparison With Conventional Radiographs, J. Periodontol. (In press.)
19. Gratt, B. M., Sickles, E. A., and Nguyen, N. T.: Dental Xeroradiography: A Rapid X-ray System Producing High Quality Images, J. Endod. **5:** 266-270, 1979.

Reprint requests to:
Dr. Barton M. Gratt
UCLA School of Dentistry
Los Angeles, Calif. 90024