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IS THERE ANY ROLE OF XERORADIOGRAPHY IN DENTISTRY: AN OVERVIEW

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ABSTRACT

Xeroradiography is a highly accurate electrostatic imaging technique that uses a modified xerographic copying process to record images produced by diagnostic x-rays. In this technique a conventional single phase dental x-ray unit is used as an x-ray source, but instead of a silver-halide film image, a uniformly charged selenium alloy plate housed in a light-proof cassette is used. In this article the equipment, procedure, properties and artifacts related to the xeroradiographic technique are described. An evaluation of the xeroradiographic images is also presented. Xeroradiography, which requires only about one-third of the dose required for conventional radiographs, is a valuable alternative to conventional radiography for detecting carious lesions, calculus deposits and periodontal disease. It is also of value in interpreting periapical structures.

INTRODUCTION

Xeroradiography is the science of recording radiographic images electronically on a selenium plate. Xeroradiography was invented by a physicist and patent attorney, Chester F. Carlson, in 1937. He based his invention on the principle of photoconductivity, i.e. some materials which are nominal insulators become conductors when they are exposed to light or ionizing radiation. Using selenium as a photoconductor, he was able to reproduce a number of graphic articles, and with the aid of another physicist, Otto Kornei, successful images were made. The basic patent covering this reproductive process was issued in November 1942. In 1947, the Haloid Company, now the Xerox Corporation, obtained a license for commercial development, and research was begun at the Battelle Memorial Institute. Investigations in the medical field started in 1952 under John Roach of Albany Medical College, New York, who discovered that xeroradiography was as sensitive as medical X-ray film when used without intensifying screens, but was several times less sensitive than film combined with screens. Thus, with xeroradiography the radiation dose would be correspondingly higher for any examination where screens are normally used with film. In 1956 a group at St Vincent's Hospital and Medical Centre of New York, under the direction of Francis F. Ruzicka jun., tried the xeroradiographic technique for hip pinnings in the theatre, but these experiments failed because of the primitiveness of the equipment available. They found their best results were in mammography, where the good visualization of both the glandular elements and the soft tissues was a striking feature of the procedure [1]. Oliphant was the first to describe an effect he called 'pull in'. This represents the 'edge effect' of the Xerox workers. In 1966 John N. Wolfe commenced experimental tests using an existent xeroradiographic unit employing a low kV technique. These experiments demonstrated the greater resolution in xeroradiography. This increase in resolution allowed identification of small structures. Especially small tumors, while the superior 'edge effect' and the good detail recorded of all the structures within the breast, made a much more accurate over-all interpretation possible.

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Encouraged by the results, a delegation of radiologists, headed by Wendell Scott, and financed by the American Cancer Society, asked Xerox to design a machine which could easily be operated, which remained clean and dry, and which could produce superb images regardless of climatic conditions. This became the Xerox System 125 [2].

Physical Principles Of Xeroradiography The principal element in xeroradiography is a re-usable photoreceptor plate, measuring approximately 24 x 36 cm. It consists of a thin photoconductive layer of selenium (130 W) adhering to an aluminum backing. The selenium layer is semi conductive. The selenium semiconductor is given a uniform positive charge by an ionizing device, consisting of a number of electrodes and a grid, called a scorotron. When the selenium plate is exposed to light or to radiation (X-rays), the semiconductor layer increases its electrical conductivity and allows the positive charge on the plate to discharge. Since the discharge of the plate varies according to the quantity of X-ray energy reaching it, an electric charge pattern, which corresponds to the density of the object being X-rayed, is left on the plate. This resultant charge pattern is the latent image. A developer consisting of a blue powder called toner is then aspirated on to the plate, to which it is attracted by the charge pattern in the form of a diffuse powder cloud. The aspiration is achieved by air jets which meter the toner into the developing chamber from a rotating disc inside a powder dispenser. The image thus formed is made permanent by transferring and fixing it by heat on a special paper. This is the xerogram (XR). An image in various shades of blue is produced. The dense regions of the subject being examined will strongly absorb the X-rays. This will allow less discharge from the plate and will lead to a stronger residual charge on the plate. More toner particles will be attracted to it and the area will therefore be dark blue in color. Thin regions of the subject will allow the X-rays to pass through almost unaffected. These cause considerable discharge of the plate and little residual charge. Only a few toner particles will be attracted and the area will be light blue in color [3].

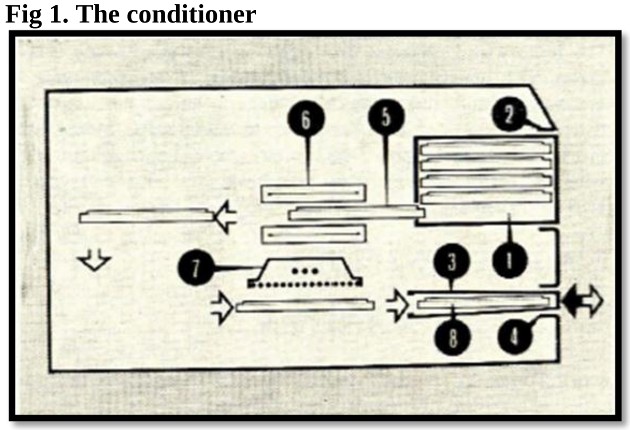
Edge Enhancement This phenomenon is one of the most important features of xeroradiography, and it is the result of the fact that extra toner is attracted to the boundaries between areas having different amounts of electrostatic charge, i.e. areas of charge discontinuity. This edge contrast is most marked at the boundaries between highly charged areas and those with very little residual charge. Edge contrast is of particular value in mammography because the fine breast structures comprising the parenchyma of the breast are depicted prominently and in great detail [4].

Positive and Negative Modes Both positive and negative modes can be used with the System 125. The positive mode is always employed with mammography and involves a slight increase in radiation exposure. The negative mode is used for all extremity examinations, for the larynx and pharynx, and for all bone work. The mode selection is by a control on the processor which, by controlling the polarity of the charges on the plate and the development chamber by means of a wire grid, attracts or repels the negatively and positively charged toner particles. For a positive image, the negatively charged particles are attracted to the controlling grid and to the plate above. For a negative image, the negative particles are repelled by the positive image on the plate and are deposited onto the discharged areas on the plate, while the positive particles move towards the body of the development chamber [5].

THE XEROX SYSTEM

The Conditioner (**Fig. 1**) This unit basically prepares the selenium plates for exposure. It will accept up to 16 plates through a slot (2), heat them in the relaxation oven (6), so that no ghost image is retained on the plate, and store them until required. When a plate is needed an empty cassette (3) is pushed into a slot (4), and this starts a transport mechanism which automatically pulls a selenium plate from storage, charges it to a high voltage by an ionizing device (7) and then loads it into the cassette (8). The cassette is exposed to X-rays in the normal manner [6].

Fig 1. The conditioner

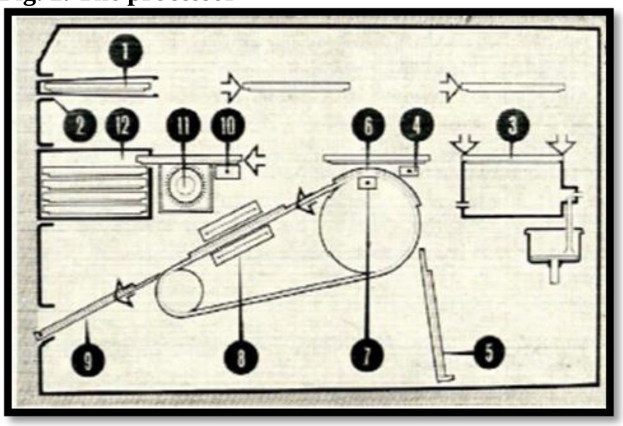


Courtesy; Brebner DM, Judelman E. (1974). An Introduction to Xeroradiography. *S. Afr. Med. I*, 48, 2289.

The Cassette This is a light-free, slightly flexible plastic container, which may be compressed if handled roughly. This will cause severe artifacts due to friction (discharge) on the selenium plate inside it. These cassettes must therefore be handled gently, and should only be held by their edges [7].

The Processor (Fig. 2) The exposed cassette (I) is inserted into the slot (2) of the processor, where the selenium plate is automatically removed. In the development chamber (3) the plate IS dusted with toner - a very fine blue powder which is negatively charged. This powder adheres to the positively charged plate and a visible image is produced. The plate now moves forward to meet a sheet of special opaque paper (6) and the image is transferred onto the paper. The paper is then heated (8) to make the image permanent. Ninety seconds after the insertion of the exposed plate, the final print is delivered at the chute (9) at the bottom of the unit. Meanwhile, the selenium plate is cleaned by a soft rotating brush (11), and is stored in the storage box (12). When this is full, it is carried to the conditioner, and the cycle is complete [8].

Fig. 2. The processor



Courtesy; Brebner DM, Judelman E. (1974). An Introduction to Xeroradiography. *S. Afr. Med. I*, 48, 2289.

PROPERTIES AND ARTIFACTS Xeroradiography has 2 major properties. It demonstrates wider exposure latitude than conventional films do, which permits portrayal of the entire spectrum of densities - from oral soft tissues to dental materials - in a single image. It also has a property called "edge enhancement", whereby small structures such as bone trabeculae, fine structural details and subtle areas of density difference are made more visible. This property is better seen when the differences in density are abrupt, and its magnitude is proportional to the amount of density difference and its abruptness of change [9]. Another important feature is that xeroradiographs, being more sensitive to x-rays than conventional radiographs, require only about one-third of the dose used for conventional radiographs [10].This reduction of exposure level obviously benefits both patients and dental personnel exposed to scatter radiation. With regard to the basic components of a radiographic image, which are contrast, noise and resolution, conventional radiographs demonstrate greater broad-area contrast and are superior for imaging gradual density changes over large areas of high radiographic density. Xeroradiographs have greater edge contrast and are superior for the interpretation of most well-defined boundaries. Noise (granularity) is slightly lower for conventional films. However, edge enhancement counter balances the greater broad-area contrast and the lower noise of conventional films. Resolution, due to edge enhancement, is significantly higher for xeroradiography and thus finely detailed structures, such as early lamina dura changes, fractures of teeth and bone trabeculae are made more visible [11]. Xeroradiographs are not only more sensitive to x-rays, but also to dust, moisture, and pressure. This results in a higher "image artifacts" index and in a higher retake rate over conventional films. It has been reported that xeroradiography demonstrates image artifacts up to 3 times more frequently than conventional radiography. The most frequently appearing artifact (toner excess spots) results from manufacturing defects in the surface of the selenium coating of the plate. This artifact which does not necessitate a retake appears as tiny black spots, not observable in dark portions of the image but easily detectable when superimposed over roots or radiopaque parts of bone. Another artifact, called volcano, appears at the edge of the images as large gray spots (usually greater than 1 to 2 mm). It does not usually require retake unless root apices are placed near the volcano. It is caused by a plate defect producing discharge prior to image development, permitting toner particles to collect at the edge of the plate [5]. The most common reason for retakes is discharge artifact, which appears as black spots larger than 1 mm, surrounded by white halos [3].The cause of this artifact is not clear, but it is probably related to dust, moisture, electricity, saliva or pressure affecting the plate and/or cassette during intraoral positioning and x-ray exposure[5]. These artifacts can be avoided by handling the cassettes very carefully in a dust-free, dry and static free environment. This is achieved with the use of a room-static eliminator, antistatic gloves and an antistatic spray on carpeting and the dental chair Double bagging of cassettes, frequent ultrasonic cleaning and alcohol dipping of the cassette lids will help to avoid excess toner residue, saliva, dust and fingerprint artifacts. While it is relatively easy to obtain duplicate images with the conventional film technique, this is not so for dental xeroradiography. Dental xeroradiographs can be duplicated using either Polaroid photography or duplicating film with some degradation of images. It seems that Polaroid photography is better matched to dental xeroradiographs since neither of them requires a dark room or wet chemicals. However, regardless of the duplicating technique, degradation in resolution, an increase in contrast and a decrease in image noise are apparent in duplicated xeroradiographs. Since there are only very subtle differences in the clinical acceptability of copy film and Polaroid photography, the decision of which duplicating technique to use is based on convenience [12].

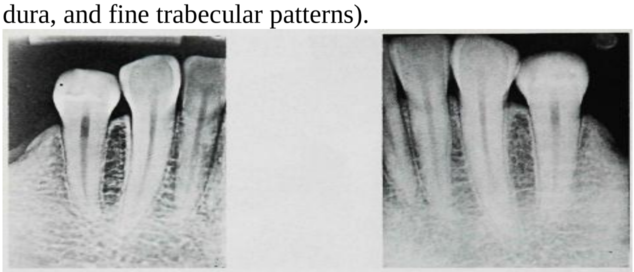
Xeroradiograpic images: - Xeroradiographs permit better visualization of the enamel cap; especially of the occlusal and marginal molars and molars where the fissures may be deep [7]. These might be useful in detecting carious lesions, especially proximal surface caries of adult and primary teeth. Indeed, although by using receiver operating characteristic (ROC) analysis (whereby one measures the performance of observers in solving specific diagnostic tasks using competing imaging systems) it has been found that there is no essential difference in diagnostic value between xeroradiographs and conventional radiographs, it has been proved that xeroradiography is more useful in detecting carious lesions[13]. The variations between observers, however, were greater than the variations between competing images. This means that the variability of opinions of what was interpreted depended more on the observers than on the competing images. Besides, it has been noted that, in both xeroradiographs and conventional radiographs, the detected caries were underestimated and the depth of the carious lesion often appeared smaller than the actual lesion. On the other hand, the accuracy of detection of the presence of a carious lesion increased as the depth of caries penetration increased [14]. With regard to cementum, there is no difference of its interpretation in both imaging systems [7]. With either imaging system, cementum is not normally seen on root surfaces. It is well known that calculus is best detected by a sharp explorer and highly developed tactile senses. However, small deposits of calculus, not evident in conventional radiographs, are observable in xeroradiographs. Heavy deposits of calculus, which are detected in both image techniques, are more clearly revealed by xeroradiographs, especially their size and extent. Further, determination of the supra- versus sub gingival location of calculus is more reliable with xeroradiographs. Xeroradiography offers well defined outlines of gingival soft tissues, whereas in conventional radiographs, gingival height and contour are not visible or are poorly defined [8].

Because of edge enhancement in xeroradiography, lines and discontinuities are seen in greater detail. Indeed, the periodontal ligament space is sharply defined in xeroradiographic images (Fig 3), in sharp contrast with the adjacent dense tooth and lamina dura [9]. This is essentially helpful in identifying individual roots that are often overlapped in multirooted teeth. Also the density and structure of the alveolar crest, and particularly the interradicular one, is better visualized by xeroradiography. Fine osseous details are also perceived more clearly [7]. Thus xeroradiographs offering accurate visualization of periodontal ligament space, alveolar crest and fine osseous details are useful in detecting initial osseous changes. This is particularly so in cases of active periodontitis, in evaluating osseous repair after periodontal therapy and in monitoring osseous changes in patients on periodontal maintenance therapy. Xeroradiographs permit better visualization of pulp chamber morphology, root canal configuration, and root outline. This is especially evident in maxillary molars and premolars, in which zygomatic arch and maxillary sinus superimpositions hinder accurate visualization of dental structures [10]. The lamina dura is also clearly observed. No diagnostic difference between xeroradiography and conventional radiography (D-speed, E-speed) was found using ROC analysis in interpreting periapical structures and periapical lesions [9-11]. However, the majority of observers subjectively preferred xeroradiographic images over film images for various diagnostic tasks. The variations between observers were also significantly greater than the variations between competing images [11]. In 1984 Peterson et al. [12] reported that the high rate of observer's variations did not decrease with the use of xeroradiography when xeroradiographs and conventional radiographs were used for the overall interpretation of periapical regions of treated, diseased and normal teeth. However, the observers viewing xeroradiographs of the periapical regions of normal teeth used the normal category more often than the probably category, compared with conventional radiographs. This means that, for these regions, the use of xeroradiography by the observers made them more confident of what they saw. A dental xeroradiograph is also a useful diagnostic tool in determining root canal length. It has been stated that although there is no diagnostic difference between xeroradiography and conventional radiography in determining the actual length of root canals, xeroradiographic images of the file for determining length are sharper and can be measured faster[10- 13]. Because of edge enhancement, bony trabeculae are seen with higher clarity, especially in interradicular areas and in bone superimposed over teeth [7]. Bony margins and areas of dense sclerotic bone are also better detected. Also, xeroradiography provides superior images conveying the extent and location of bone loss. However, conventional radiographs having greater broad-area contrast are more useful for the interpretation of area densities [8]. This means that conventional radiography is judged superior than xeroradiography, as it interprets very large areas of bone (>2 cm) such as the overall density of trabeculae bone in the periapical region. With regard to the interpretation of jaw lesions, although xeroradiographs and conventional radiographs are of equal diagnostic value, xeroradiography produces images that are sharper in clarity and fine detail [12]. Indeed, cortical lesions detectable in both competing image techniques are visualized in more clarity and more details in xeroradiographs. The x-ray beam, independently of the imaging system, can interpret a cortical lesion only when the percentage of mineral bone loss is equal to 6.6% or above [13]. With respect to medullary lesions, no diagnostic difference is apparent. However, the lesion's borders are more clearly defined on xeroradiographs. Central bone lesions, confined to cancellous bone between cortical plates, are not detectable on either xeroradiographs or conventional radiographs until destruction of the junctional trabeculae occurs. Xeroradiography enables definition of the actual margins of the lesions more easily, as it can reveal fine details of the trabecular pattern [14].

Further, xeroradiography, by permitting visualization of fine osseous details, may prove more useful in evaluating the stress forces involved in occlusal analysis. This, combined with superb delineation of subtle wear patterns of the enamel cusps of teeth available from xeroradiography, permits more precise evaluation of probable occlusal dysfunction [15]. In a study involving 12 pre- and post-treatment oral cancer patients, xeroradiography was found to be superior to conventional techniques in interpreting fine osseous patterns, bone erosions and soft tissues. Fine bony structural details, especially details of bone trabeculae and exophytic bony changes, are better perceived on xeroradiographs, permitting more accurate assessment of the extent of bone involvement in oral cancer. Besides, the borders of bone erosions were more clearly defined and early bone loss due to invasive squamous cell carcinoma (floor of the mouth) was visible only on xeroradiographs. Thus, it is possible to determine of whether a cancerous lesion has invaded bone or whether recurrence is present. This might help in planning the treatment of a patient with suspected or known oral cancer. The soft tissues of the lateral border of the tongue and of the floor of the mouth, as well as gingival borders were also better visualized with regard to their shape, size, density and texture. Thus, any alteration of them was easily detectable. Although the soft-tissue radiographic features of carcinoma are unknown, xeroradiography can detect and characterize any such change. Also, calcifications of oral soft tissue not evident on conventional radiographs are detectable on xeroradiographs [4]. Common dental restorative materials, and especially radiolucent and mild-to-moderate radiopaque. One such as composite and acrylic resins, base materials (calcium hydroxide, zinc phosphate cement), intermediate restorative material (zinc oxide and eugenol), gutta-percha, root canal sealers (pastes), porcelain, aluminum, foreign bodies (amalgam flakes) and aluminum oxide endosseous implants, are better interpreted on xeroradiographs.

Dental xeroradiography and film techniques are of equal value for the imaging of highly radiopaque materials, including amalgam alloys, gold restorations, pontics, silver points, retrograde alloys, dental pins, dowels and wires. Conventional radiography is superior to xeroradiography for the interpretation of large radiopaque substances (gold, amalgam) when improper xeroradiographic processor settings are combined with improper radiation exposure parameters. In addition, when high edge enhancement setting is combined with excessive radiation exposure, radiolucent artifacts may appear due to excessive edge enhancement. The artifact appears as a radiolucent area, located around the outside margins of dense metallic restorations, superimposed over the tooth structure next to the restorations. This area resembles recurrent caries and may result in needless removal of a restoration in an otherwise normal tooth [15]. Fortunately; the artifact effect can be controlled by decreasing radiation exposure and/or by proper electrical setting of the xeroradiographic processor. For example, low contrast xeroradiographs viewed in transmitted light reduce significantly the appearance of the artifact. In cases of questionable artifact, the simple solution is to take a second xeroradiograph using the proper conditions. True recurrent caries will be apparent, whereas artifacts will not. In the 1970s xeroradiography was used in cephalometric analysis. A common clinical problem of conventional cephalometric radiographs is the difficulty of obtaining good soft-tissue images of the lips and chin, while maintaining clarity of osseous landmarks. Dental xeroradiography permits better interpretation of soft tissues [4]. Since xeroradiographs have wider exposure latitude, this technique was rendered as a possible alternative. Despite these advantages of xeroradiography, there is no difference between cephalometric xeroradiographs and conventional cephalometric radiographs in terms of identification of cephalometric landmarks. The accuracy of locating points is increased by xeroradiography, but since cephalometric analysis is used as an adjunctive aid, conventional radiographs provide sufficient data [16-17].This was somehow anticipated, since the osseous landmarks were employed in order to be easily visualized on conventional cephalometric radiographs. Proper modification of the conventional technique can highlight soft tissues, thereby minimizing the advantage of xeroradiography. Variations between observers, in identifying cephalometric landmarks are not reduced by either of these 2 competing radiographic techniques. However, as xeroradiography permits more consistent reproducibility of landmark identification between each observer's own attempts, the intraobserver differences are reduced significantly [18]. Xeroradiographic plates are less sensitive than screen/film combinations to x-rays and thus require a higher radiation dose. The thyroid dose, for example, is higher by a rate of 60:1, and the bone marrow dose is approximately 100 times greater than by a rare earth combination system. Although the patient's dose in xeroradiography can be reduced (by adding a copper filter 0.2 mm thick it is reduced by 50%, it is still significantly higher in comparison with conventional cephalometric technique. It is widely known that a patient's threshold dose has not yet been accurately determined and so it is impossible to speculate if a radiation dose is within an acceptable range. The policy of minimizing radiation to a patient unless a larger amount is justified by an anticipated increase in diagnostic information is wise, and thus xeroradiography is not recommended for routine cephalometry [19]. A cephalometric xeroradiograph can be used in cases in which the most important issue is the increased radiographic information and not the possibility of radiation damage, if any, to the patient. Cephalometric xeroradiographs can be used in the diagnosis and in the presurgical planning of maxillofacial problems such as benign and malignant lesions, which may be outlined with difficulty on conventional radiographs, since cephalometric xeroradiographs provide better simultaneous visualization of bone, cartilage and soft tissues [17-19].

(Figure 3) A xeroradiograph (A) and an X-ray film (B) of the mandibular canine and first premolar are compared. The xeroradiograph provides an excellent outline of the teeth including crowns, roots, and pulp chambers, and better defines the periodontal ligament spaces, lamina dura, and fine trabecular patterns).



Courtesy: Bernadette MT. (1980). Xeroradiography Adds New Dimension to Intraoral Imaging. *Quintessence International*, 2, 6.

(Figure 4) The first step in the xeroradiographic process is inserting an empty cassette into the system. The unit automatically places an electrostatic charge on a photoreceptive plate stored inside and loads the plate into the cassette. In three seconds, the sensitized cassette is released and ready for X-ray exposure.

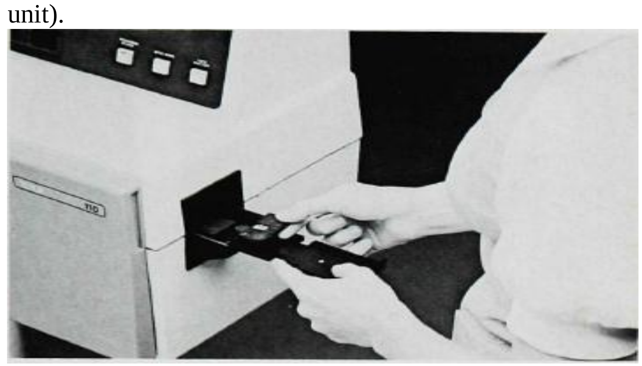
Courtesy: Bernadette MT. (1980). Xeroradiography Adds New Dimension to Intraoral Imaging. *Quintessence International*, 2, 6.

(Figure 5) To prevent contamination, the reusable cassette (containing the sensitized plate) is placed inside a disposable plastic bag. This may be inserted in a holder or bitewing tab and positioned in the mouth for routine intraoral views.

Reduced Exposure Time Dental xeroradiography can significantly reduce X-ray exposure time. Xeroradiographs made with a prototype system required from one-half to one third the exposure time of conventional intraoral films. The new Xerox 110 system is compatible with standard dental X-ray equipment operating in the usual 60—100 kVp range (Fig. 6).

Courtesy: Bernadette MT. (1980). Xeroradiography Adds New Dimension to Intraoral Imaging. *Quintessence International*, 2, 6.

(Figure 6) The Xerox 110 is compatible with all standard intraoral radiographic equipment. When the exposure is made, X-rays interact with the reusable xeroradiographic plate (which replaces X-ray film) forming an electrostatic "latent image" on the plate. To make this image visible and permanent, it must be processed in the Xerox 110 unit).



Courtesy: Bernadette MT. (1980). Xeroradiography Adds New Dimension to Intraoral Imaging. *Quintessence International*, 2, 6.

Reusable Image Receptor A reusable photoreceptor plate replaces X-ray film in the xeroradiographic system and can be used for numerous exposures. Plates are available in two sizes corresponding to No. 1 and No. 2 periapical films. Rigid xeroradiographic cassettes protect the plates and are slightly thicker than conventional intraoral film cassettes (Fig. 5). They are positioned with conventional film holders

(Fig. 5). Because the cassettes and plates are reusable, they are wrapped in a sterile, disposable plastic bag before positioning in the mouth. Interpretation and treatment discussion with patients (Fig. 9).The xeroradiographs looks like a photograph and can be viewed in room light, but maximum information may be seen when images are observed with a view box. Xeroradiographs consist of special black pigment sandwiched between two layers of protective plastic. They are scratch proof and can be marked with a pen or pencil for positive patient identification. Images may be stored in series or separated and inserted into conventional X-ray film mounts.

(Figure 7) The operator removes the exposed cassette from the mouth, discards the plastic wrapper and inserts the cassette into the Xerox 110. The system removes the exposed plate and releases the empty cassette for reuse. The system then automatically develops the image on the plate, transfers and permanently fuses the image to plastic. The plate is cleaned and stored for reuse

Courtesy: Bernadette MT. (1980). Xeroradiography Adds New Dimension to Intraoral Imaging. *Quintessence International*, 2, 6.

A dry, permanent xeroradiograph is available for viewing in 20 seconds. Exposures for the same patient exam are delivered on a convenient imaging strip, which is protected by a durable plastic coating. Immediate image access permits evaluation of xeroradiographs while the patient is still in the chair.

(Figure 8) Rapid delivery of xeroradiographs permits the operator and dentist to evaluate image quality and review treatment without delay. Images may be viewed in ordinary reflected room light or transilluminated with a view box. The superior detail of xeroradiographs makes them easier for patients to view and understand than X-ray films.

Courtesy: Bernadette MT. (1980). Xeroradiography Adds New Dimension to Intraoral Imaging. *Quintessence International*, 2, 6.

CONCLUSION

Xeroradiography, with the exception of cephalometry, is characterized by low radiation exposure. It requires only about one-third of the required dose for conventional radiographs, has wider exposure latitude, and a unique property termed edge enhancement. With these features, and several features of convenience, xeroradiography is a valuable alternative to conventional radiography for the detection of carious lesions, calculus deposits and periodontal disease. It is also of value in interpreting periapical structures.

Additionally, the exceptionally fine detail offered by xeroradiography facilitates detection of initial periapical changes and evaluation of periapical healing after endodontic therapy. Because of edge enhancement, jaw lesions are also more clearly visualized on xeroradiographs. With regard to oral cancer, xeroradiography provides valuable preoperative information for treatment planning and permits serial radiographic evaluations of postsurgical and irradiated areas with a decreased risk of excessive radiation exposure. Xeroradiography also has greater exposure latitude, so it offers better simultaneous portrayal of dental restorative materials and hard and soft tissues.

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