C. MAXILLO—FACIAL DIAGNOSIS

Dr. Allan B. Reiskin
University of Connecticut Health Center
School of Medicine

The use of fluoroscopy in dental practice is uncommon for many reasons. Dynamic studies, for which fluoroscopy is best suited, are not often required. The cost of currently available devices is extremely high, the units are large, and image detail is poor compared to film. While the Lixiscope in its present form has made substantial progress toward resolving the problems of the cost and size, image quality is still a problem.

As illustrated in Figure 1, the structures which are dealt with in dentistry are extremely small. The periodontal ligament which forms the attachment of tooth to bone is only a fraction of a millimeter wide. A change in the size of this space is often one of the most significant indications of incipient but treatable disease of the tooth, its supporting bone, or its attachment. A doubling of the size of the ligament space may represent less than one quarter of a millimeter, and therefore, images must be capable of resolving these extremely small changes to be of primary diagnostic value. The periodontal ligament space was selected as an example of the dimensional requirements of X-ray diagnosis in dentistry because it is similar in size to a variety of normal and pathological structures which are of importance.

The image in Figure 1 was produced with Kodak ultraspeed film. Its resolving power is illustrated by

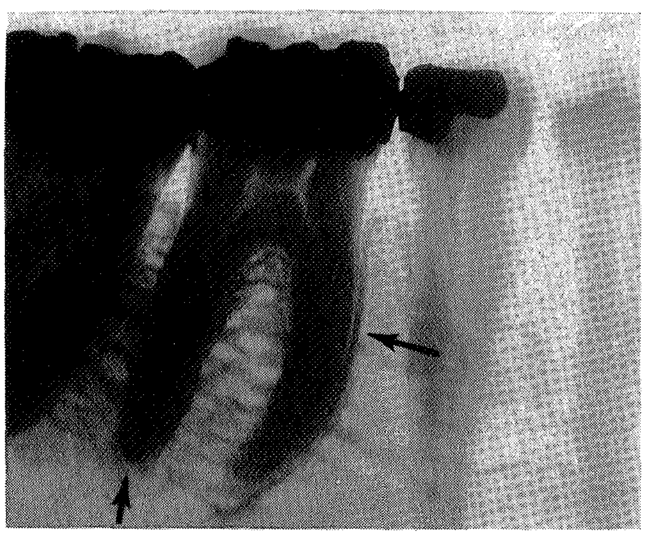

Figure 1(a). This radiograph represents a view of the roots of molar and premolar teeth. The attachment of tooth to bone (the periodontal ligament) is indicated by the arrows.

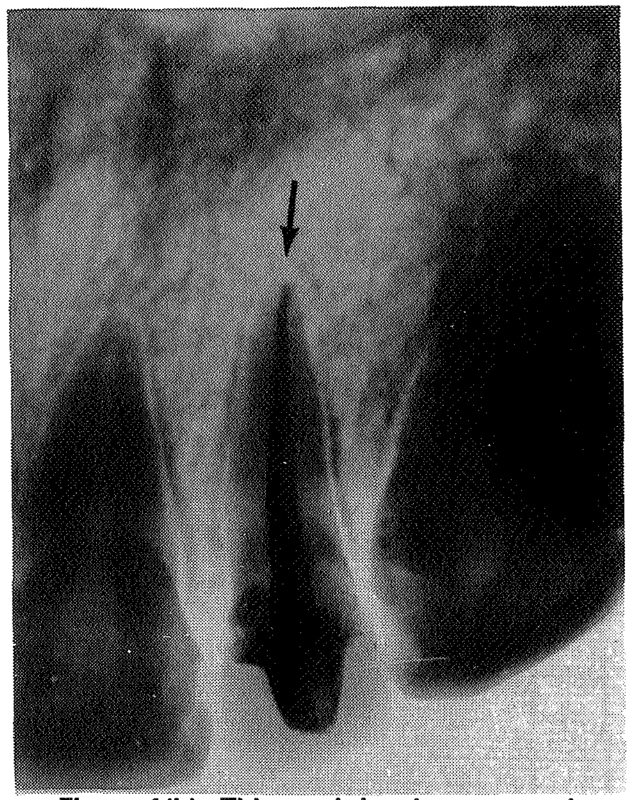

Figure 1(b). This tooth has been treated endodontically, that is vital tissue has been removed and replaced with a sterile dressing. The attachment at the apex of the root is thickened (arrow) indicating residual disease.

use of a test pattern shown in Figure 2. The films are quite small (Figure 3) because most dental structures are paired and would superimpose upon each other if both the radiation source and the image receptor were outside of the oral cavity. In current practice, it is the image receptor which is inserted into the oral cavity, although this projection geometry can be reversed by using either rod anode X-ray tubes or isotopic sources such as those described by Dr. Webber and others (see reference).

In addition to the high resolution radiographs already seen, other types of diagnostic images are used in dentistry. A thick section tomogram (panoramic) is shown in Figure 4. This image reveals a disadvantage of static images, namely artifact associated with movement. The illustration reveals the image of a bony fracture with all of the

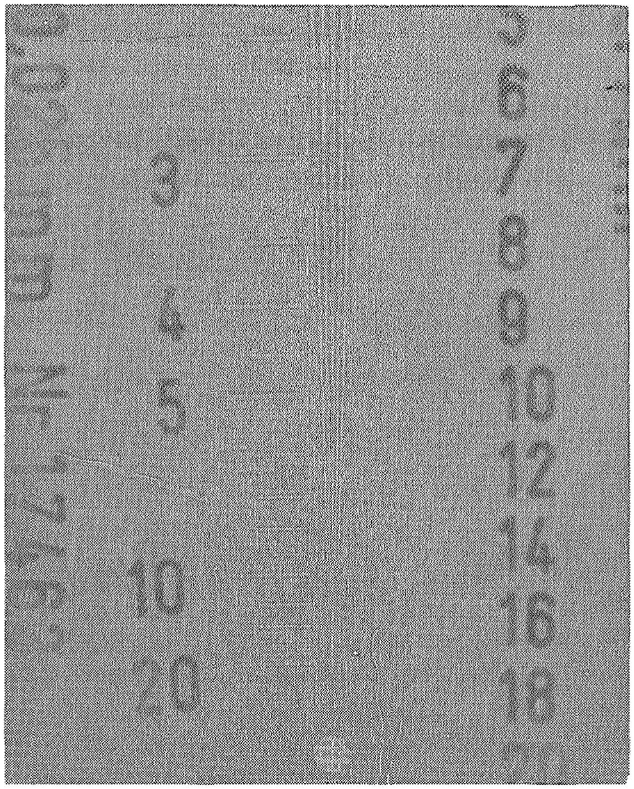

Figure 2(a). This image of a lead test target was made on Kodak ultraspeed film using 90 kVp X-rays and standard processing conditions. With magnification, one can resolve 20 line pairs per millimeter.

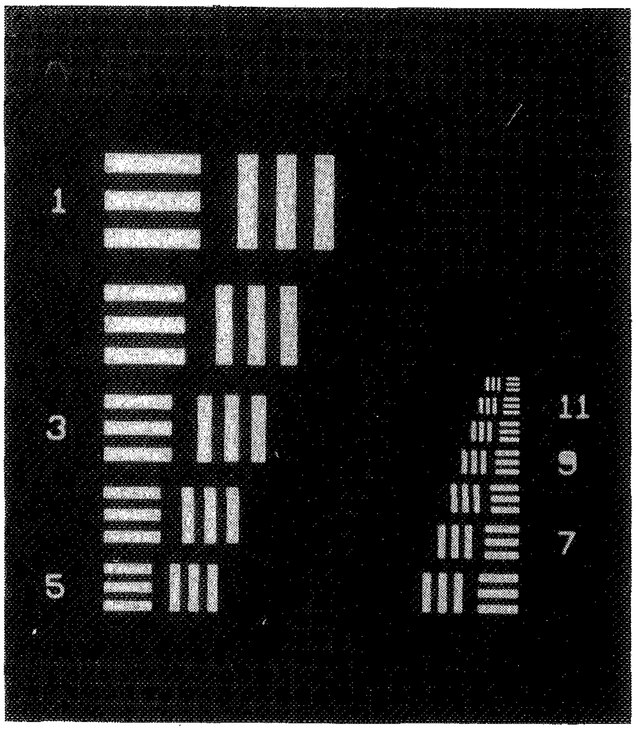

Figure 2(b). A bar pattern used for assessing focal spot size was also imaged on Kodak ultraspeed film and confirms the high resolution observed with the diverging lines.

Figure 3. A coin was placed on top of a dental film to illustrate its relative size. Courtesy of the Eastman Kodak Co.

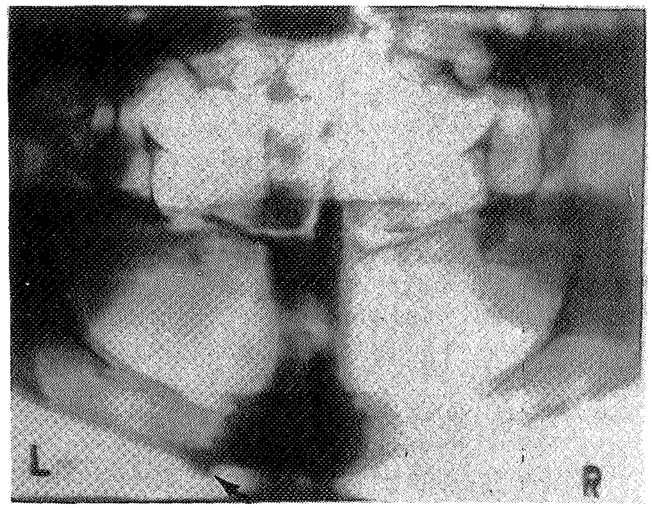

Figure 4. The defect indicated by the arrow represents motion artifact.

radiographic characteristics that one expects to see in a classical case of trauma. In reality, however, the fracture is an artifact which resulted from the sudden movement of a patient during the exposure (16 sec.). The dynamic nature of Lixiscope images would certainly reduce the probability of confusing this type of artifact with genuine trauma.

Figure 5 shows a thin section tomogram through the articulation between the mandible and the cranial base. In this, as in other instances, it is found that thin section tomography, which is a comparatively high dose procedure, is necessary because anatomical constraints do not permit one to view this area adequately with conventional imaging systems. However, the reversed geometry which could be used with the Lixiscope might eliminate the need for tomographic examinations in many patients. The

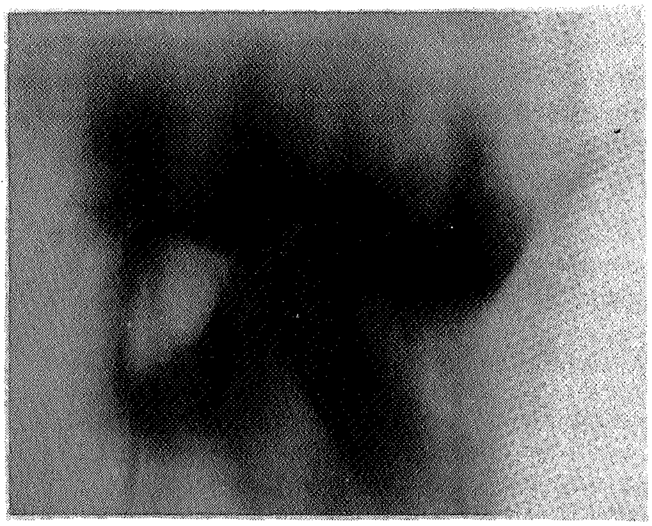

Figure 5. This tomogram represents a thin section (approximately 1 mm) using a linear tomographic system and a 40° angle.

Lixiscope would also provide a less expensive substitute for the tomographic equipment which is now required.

The evaluation of any imaging device must ultimately include a consideration of the radiation economy of the image detector. There can be a considerable dose-sparing affect by reversing the geometry of image production in some dental procedures. This reversal, compared to more commonly used geometries, reduces the total amount of tissue which is exposed in the radiation field. However, as shown in Figure 6, one can use collimating devices which ultimately provide the same dose-sparing affect achieved by reversing the geometry. As long as the radiation field is no larger than the size of the image receptor and shielding is provided to prevent penetration beyond the plane of the film, then substantial savings can be attained. Under these conditions the dose-sparing advantages of reversed geometry may be less dramatic.

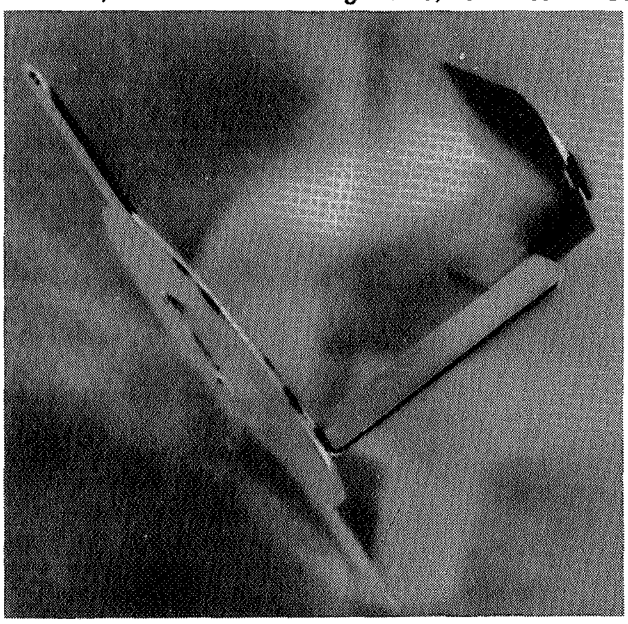

Figure 6. A large number of collimating devices are available for use with dental films. This particular instrument is made of stainless steel and restricts the X-ray field to the size of the film. A metallic backing behind the film prevents penetration of the X-ray beam beyond the image plane.

It is important to remember that there are problems other than the small size of the objects which are dealt with and the exposure requirements of any particular system. For example, the reduction of a three-dimensional object to a two-dimensional image can result in significant information loss. Small changes in angulation can have dramatic effects on the information content of a resulting radiograph and in many instances it is impossible to predetermine the optimal projection geometry without some type of system for previewing the final image. In spite of its relatively poor resolution, the Lixiscope might provide a simple and inexpensive device for previewing projection geometry prior to the production of an image on film. Such a procedure may be practical because of the Lixiscope's high gain. Obviously, the Lixiscope could be used either with isotopic sources (see reference), or with an extended rod anode X-ray source shown in Figure 7. Rod anode x-ray sources are commercially available and have been used for a variety of diagnostic procedures in the maxillofacial region. The configuration and size of the x-ray source make it possible to insert the device into the oral cavity so that any imaging device can be placed in an extra-oral position. Combined use of the Lixiscope as a previewing device with high resolution hard copy films should reduce the total number of films and improve their quality.

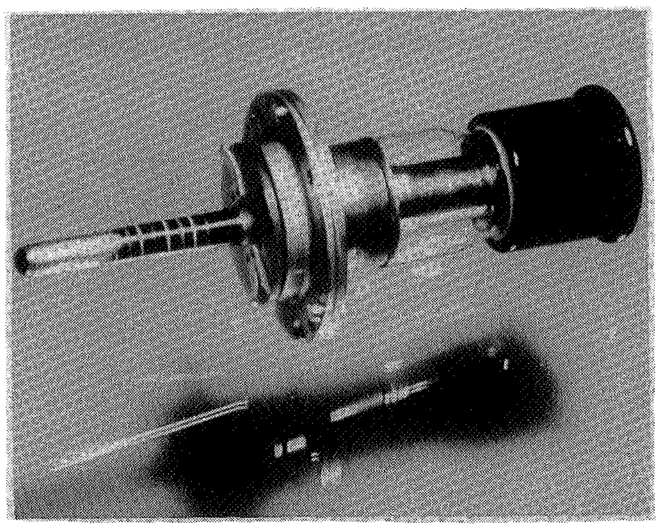

Figure 7. This illustrates the tube of a Siemens Status-X device. X-rays are emitted from the end of the tube which is small enough to be inserted into the oral cavity. Courtesy of the Siemens Corp.

A further advantage of extended rod anode x-ray sources and reversed geometry is the possibility of using extremely small focal spots and magnification as a means for improving image quality. In order to assess the impact of source size and other factors on image quality with the Lixiscope, we conducted several preliminary studies. Resolution was measured with a variety of test targets using bar and star type patterns. The data is summarized in Figure 8. Studies were conducted with x-ray sources having different spectra, including narrow energy bonds produced with rare earth filters and conventional sources. Isotope sources of iodine and gadolinium were also used. The sources varied in size from approximately six tenths of a millimeter to more than one millimeter and source to object distance was varied from a few inches to several feet. Under these conditions, images were produced on two Lixiscopes with different gain characteristics. Both instruments had variable gain controls and each was used in extreme high gain and low gain settings. The basic conclusion of our studies was that the resolution of these Lixiscopes was limited by several factors to approximately four line pairs per millimeter. First, the phosphor which converts radiation to light in these prototypes was relatively coarse. Second, since both instruments produced higher quality images in their low gain modes and the low gain instrument produced an image with greater resolution than its high gain counterpart, we presume that internal problems such as ion feedback near the surface of the microchannel plate or poor contact between screen and fiber optic might limit the resolution of the Lixiscope to levels which are below the requirements of many diagnostic procedures. It is also important to note that resolution measurements were made by recording images on Polaroid films which required relatively long exposure times. The resolution data which we obtained included the integration which is achieved by the film over a period of time. This integration is considerably greater than that which can be achieved by human eye and our measurements may be deceptively high. Our conclusions should also be qualified by the observation that there were consistent differences between measurements made with each test target and it was not possible to determine which of the test targets provided the most appropriate type of measurement.

Thus far, the Lixiscope evaluation has been in the context of a primary diagnostic device. It is important to recognize, however, that there are many situations in which an imaging system is used in conjunction with, or as support for, other procedures. A procedure has been described in which the Lixiscope was used to obtain working information during endodontic procedures. Similar uses of the Lixiscope might be made at other anatomical sites during other types of clinical procedures. Prime examples include arthrography and sialography. In these procedures, contrast agents are used to fill joint cavities or the ductal structures of salivary glands. These are usually dynamic studies in which it is important to establish that the contrast agent is deposited at the correct anatomical site and flows according to some predictable pattern based on our knowledge of normal anatomy and physiological function. Figure 9 shows a Lixiscope image of a needle placed in the knee joint of a rabbit. The size of the needle and the size of the joint are similar to what we would encounter in a human temporomandibular joint. The ability to manipulate the Lixiscope around the joint proved to be an enormous advantage in correctly placing the needle. On the other hand, the Lixiscope had the disadvantage of making the production of a hard copy record extremely difficult. Because exposure times were relatively

LIXISCOPE RESOLUTION

		RESOLUTION (L.P./mm)	
MCP	SOURCE	Max. G.	Min. G.
H.G.	70 kVp x-ray	4.0-5.0	5.0
H.G.	36 kVp x-ray	2.2-4.0	
H.G.	^{153}Gd	3.5	3.0-4.0
L.G.	36 kVp x-ray	5.5	
L.G.	70 kVp x-ray	4-5.5	
L.G.	^{125}I	4-7	

Figure 8. Resolution measurements made under different conditions with different Lixiscopes are summarized. Resolution of four or five line pairs per millimeter may not be achievable by direct viewing and may represent a gain resulting from integration accomplished by the film.

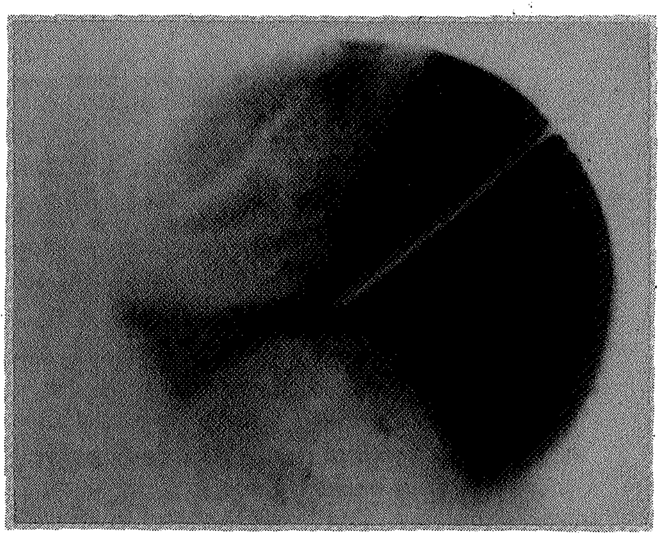

Figure 9. Shows a needle inserted into the knee joint of a rabbit. All of the structures are sharply defined including the bevel on the needle.

long, it was not uncommon to produce images such as that seen in Figure 10 with a large blur fringe that obscured detail. By comparison, Figures 11 and 12 show temporomandibular joint arthrograms photographed on Polaroid film from a video screen after recording on a magnetic disc and a similar image obtained on film by a tomographic procedure. Figure 13 shows a plain film of the same site which was necessarily taken at an oblique angle. Although the image quality is relatively high, the projection geometry required to view this site compromises the utility of the examination. Direct lateral viewing which could be achieved with an intraoral source and a Lixiscope would have distinct advantages.

In conclusion, the very brief experience with the Lixiscope established several points. First, in its present configuration, the Lixiscope appears to have value primarily as a previewing device for conventional radiography or as a working instrument to be used in association with or in support of other procedures. Second, the Lixiscope, in its existing configuration does not have sufficient resolution to function as a primary diagnostic tool for most dental needs. Finally, it is necessary to emphasize that we have examined primitive models of the Lixiscope and the technology for substantially improved devices already exists. Sufficient information has been developed to support the desirability of constructing second and third generation Lixiscopes with larger and more uniform fields, with advanced design, microchannel plates, and with improved phosphors.

Reference

Henrikson, C. O.: "Iodine 125 as a Radiation Source for Odontological Roetgenology," Acta Radiologica Suppl., 269, 1967.

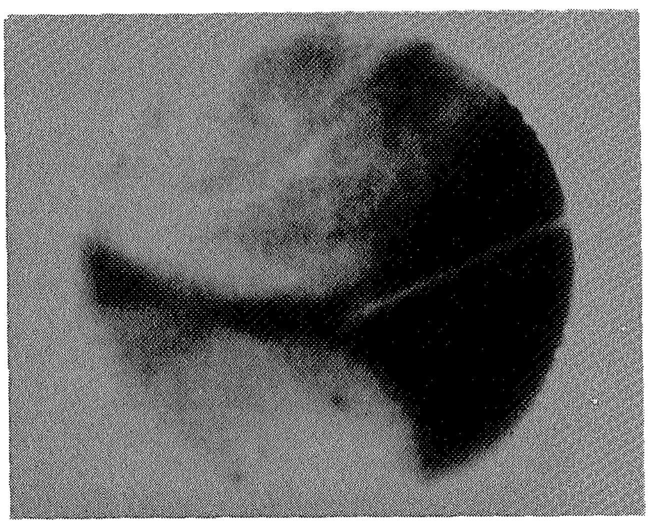

Figure 10. This image shows the result of motion introduced as a result of long exposure times. A blur fringe can be seen along the edge of the needle and less clearly, at the edge of bone.

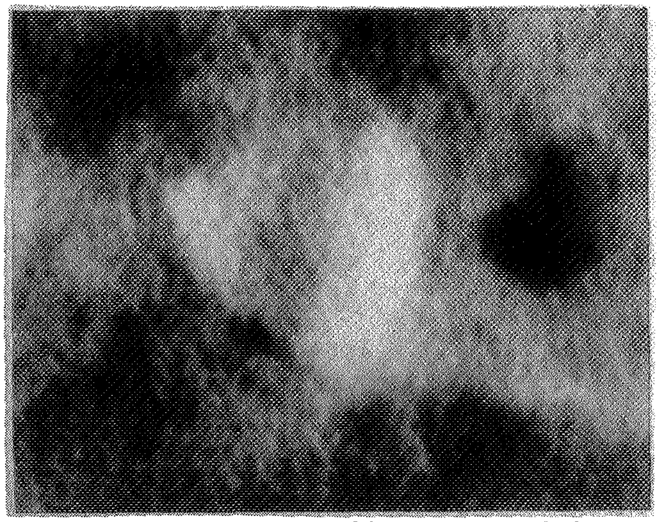

Figure 11. The quality of images recorded on magnetic discs may be significantly poorer than those visualized directly on a Lixiscope screen.

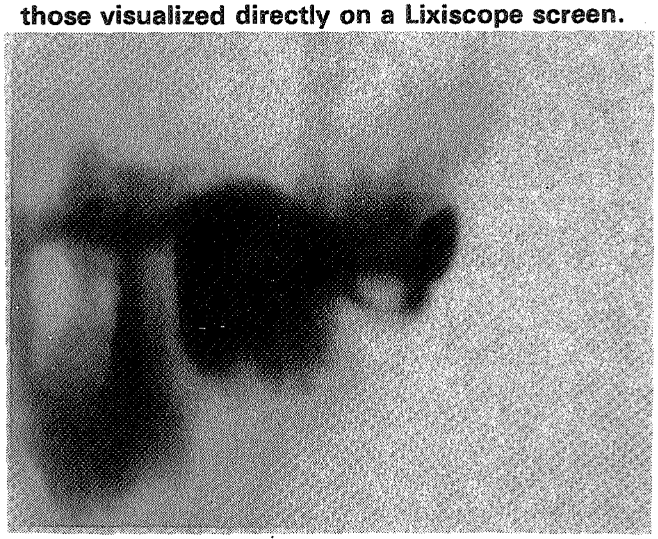

Figure 12. The Lixiscope and the video disc do not compare in image quality with thin section tomograms such as that illustrated here.

Figure 13. Greater sharpness and detail is obtained in plain films such as this arthrogram in which the lower compartment of the temporomandibular joint has been filled with opaque material.