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A Technique for Studying the Spacial Relationship of Oral Hard Tissues Utilizing Panoral Radiography

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A TECHNIQUE FOR STUDYING THE SPACIAL RELATIONSHIP OF ORAL HARD TISSUES UTILIZING PANORAL RADIOGRAPHY

by

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Master of Science in the Field of Orthodontics

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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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CHAPTER I

INTRODUCTION

Importance of the Research:

The intent of this investigation is to provide a scientific method for documenting radiographic evidence concerning amount of growth, direction of growth, and changes in position of the hard tissues of the oral region during growth by use of panoral radiography.

Objective of the Research:

To develop a technique of positioning the patient during panoral radiography, so repositioning of the subject for subsequent panoral radiographs can be accomplished with accuracy, ease and dispatch. This would permit, with proper superpositioning of serial panoral radiographs, a study of growth and change of position of hard tissues of the oral region.

CHAPTER II

REVIEW OF THE LITERATURE

HISTORY OF PANORAL RADIOGRAPHY

Paatero (1949), working at the Institute of Dentistry, University of Helsinki, Finland, reported a new tomographic method for radiographing curved outer surfaces. He used two methods:

1. A curved stationary film with the source of radiation stationary and the patient and chair rotating 180°.

2. A straight moving film with the patient and chair rotating 180°.

Nelson and Kumpula (1952) reported the development of a rather elaborate mechanism by them at the University of Washington in Seattle, Washington. The technique was termed "panographic radiography." They used a curved film which was positioned on the lingual side of the dentition. The reported technique utilized a dried skull.

Paatero (1954) reported rather substantial improvement in the equipment used in panoral radiography since his first article concerning this subject in 1949. He reports having spent one and one-half years at the University of Washington in Seattle, working in conjunction with the research being carried on there on panoral radiography. Stereoscopic panoral radiography, a further innovation is discussed by him and has been accomplished with considerable success in the final product.

Sydney Blackman (1956) of the Royal Dental Hospital in London, England reports that:

> "Potentialities are many and the advantages great, for the examination is carried out with one film placed outside the face with no distress to the patient. As soon as a child is able to sit upright in a feeding chair it will become eligible for a pantomographic dental examination."

At this time the apparatus had been perfected so it could be employed on a wide scale for mass dental radiography. The time necessary to take a pantomograph (panoral radiograph) had now been reduced to three to four minutes, including the twelve second radiographic exposure.

Hudson and Kumpula (1957) described the need for mass radiography for persons entering military service to provide evidence of general dental health and information on dental treatment requirements and records of identification. They felt at this point that rotating the x-ray source was easier to accomplish than rotating the patient.

The X-ray Manufacturing Corporation of America (1959) reported the development of a panoramic dental x-ray machine, which they called the "Panorex." This self contained x-ray machine was designed as a survey type machine. X-ray radiation was reported to be far less than that derived from a conventional 14 or 18 film full mouth survey.

Kumpula (1961) gives a report of the current status of panoramic roentgenology. The development and construction of panoramic dental x-ray machines demonstrate that full mouth dental roentgenograms on a single extra-oral film can be produced. Employment of several techniques produce a variety of roentgenograms with adequate detail to obtain a diagnosis of general oral status. Panoral radiography is not intended as a substitute for, but as an adjunct to conventional dental roentgenography.

SOME METHODS OF STUDY OF BONE GROWTH

Vital Staining: Use of Madder

Belchier (1736) was one of the first and perhaps the very first investigator to call attention to the fact that bone had a very definite affinity for madder, an organic dye. Duhamel (1739) should receive the credit, however, for proving that only growing bone exhibited this characteristic. He was the first to describe the manner of bone growth. Hunter (1771) applied the same method to a study of the growth of the mandible in the pig, and accurately described the sites of growth of the body of this bone as well as that of the alveolar process associated with the eruption of teeth. Brash (1924, 1934) repeated Hunter's work, also using a pig, and came to very similar conclusions regarding the growth of the mandible. It should be noted at this point that the inclusion of madder in the diet creates an abnormal diet for animals and may affect their pattern of growth.

Use of Alizarin Red S:

Animals other than fowl and the pig family do not readily eat food in which madder is placed. This problem lead to the search for a material which could be administered hypodermically. This material (ali zarin red S) has been employed by Schour (1936), Levine (1940), and Massler (1941) in the study of the head growth of rabbits, rats and monkeys.

Anthropological:

Dried mandibles have been examined grossly since the inception of osteometry in ancient Egypt and Greece. This is a static cross-sectional method of the study of bone growth. The superposing of dried bones has been used frequently to study areas of growth.

Welcher (1896) pointed out the value for anthropological investigations, and of radiographs of the head in profile. This method has been used for that purpose by Beglund (1914), Lilja (1939), on living material and Mellquist and Sanberg (1939) on crania.

The earliest methods to be utilized in growth studies of the head was that developed by physical anthropologists employing given points, planes, and angles thereby attempting to describe racial differences. These methods eventually were adapted to growth sites of different age groups where sufficient material was available. Hellman (1927, 1933) did outstanding work in this field. He investigated a large series of Indian skulls, and later made a similar application to living persons. Goldstein (1936) and Davenport (1940) did similar work on living individuals. Keith and Campion (1922) attempted to analyze the growth of the head by comparing bone for bone, three crania representing different ages. Krogman (1930) published an exhaustive series of comparative studies involving man and the higher anthropoids.

Histological:

Histologic study of the pattern of bone growth is difficult because of constant modeling and rebuilding. Bhaskar (1953) compared prenatal and postnatal growth and development in the mandible of normal rats and in a certain group of rats that were characterized by retardation of bone resorption.

Histochemistry:

Sarnat (1960) reports that histochemical studies are valuable in obtaining further information about the nature of bone formation. The importance and location of various enzymes and other substances such as glycogen and glycoproteins have been determined.

Implant markers:

Hunter (1771) placed two metal pellet implants in the shaft of the tibia in a young pig and recorded the distance between the pellets. After the tibia was fully grown he examined the tibia and found that the measurement between the metal pellets had not changed. This was conclusive evidence that interstitial bone growth had not taken place. Humphrey (cited from Brash, 1924) placed a wire loop around the ramus of a pig mandible and demonstrated that there was deposition of bone tissue on the posterior border and resorption on the anterior border of the ramus of the mandible. This direct method does not permit serial data unless the animal is reoperated or sacrificed.

Bjork (1955) studied bone growth by the use of vitallium metal implants in humans. Three or four metal pins were driven into each, the mandible and the maxilla. Periodic cephalometric radiographs were taken, and the amount and direction of bone growth was documented. In all cases thus studied by Bjork the period of observation was two years.

Roentgenography:

Symons (1951) studied the angular relationship of the occlusal plane of the mandible with the body of the mandible. He superposed roentgenographic tracings of adult human mandibles on a line joining the center of the head of the condyle to the mental foramen. This method is a refinement of the cross sectional method in that roentgenography and superpositioning of roentgenographic tracings were used on supposedly stable bony landmarks. The pattern of growth thereby was demonstrated.

Serial Cephalometric Roentgenography:

Serial roentgenography permits a longitudinal study of the same individual during the period of growth. It is imperative in the employment of this method to select stable anatomical landmarks for roentgenographic tracings. If the anatomical landmarks are unstable, the results will be erroneous. The rate, the amount, and direction of bone growth may be assessed by this manner. This method does not reveal the sites or the manner of bone growth.

Broadbent and Hofrath (1931) simultaneously but independently described a technique of controlled cephalometric roentgenography. The accuracy of this method is dependent upon standardization of the technique of roentgenography. The target-film distance is constant. The patient is therefore positioned and repositioned to the cephalometer rather than adjusting the cephalometer to the patient. Sella turcica was believed to be a stable anatomical landmark and therefore was used for superpositioning of roentgenographic tracings of human crania. The superpositioning of serial tracings would yield information concerning bony change. Measurement of the change is thereby made possible.

Brodie (1941) was the first to apply Broadbent's method to a longitudinal growth study of the crania of male children from three months to eight years of age. Brodie superposed tangents to the lower border of the mandible as a base line for the serial roentgenographic tracings made from serial studies of mandibular growth. The angle formed by this line with a tangent to the posterior border of the ramus of the mandible was bisected to locate gonion, the point of superposition. This method was predicated on the supposition that there was minimal or no growth at the lower border of the mandible.

Serial Roentgenography and Implantation:

A more accurate and reliable method of studying growth is obtainable by using a combination of serial roentgenography and metallic implants. Those using this method of growth studies were: Black (1948) in a dog palate, Hulen (1948) in a dog mandible, Gans and Sarnat (1951) in monkey facial sutures, Selman and Sarnat (1957) in a rabbit snout, and Robinson and Sarnat (1955) in a pig mandible. Stable reference points are obtained by the insertion of two or more metallic implants in the bone being studied. Serial roentgenograms at predetermined intervals demonstrate the hard tissue change by superpositioning of the metallic implant images. This method yields an accurate assessment of growth changes.

One of the additional advantages of this combined method of serial roentgenography is the ability to measure the quantity of new bone formation, or quantity of bone resorption without sacrifice or reoperation of the animal. Employment of this method does not interfere with the normal diet of the animals.

SOME METHODS EMPLOYED IN THE STUDY OF TOOTH ERUPTION

Histological:

Orban (1957) describes the histology of eruption of teeth. He made buccolingual histologic sections through the lower central incisors of seven consecutive stages of eruption from a newborn infant to nine years of age. Buccolingual sections were also made through lower deciduous molar and first premolar areas of eight consecutive stages from newborn infant to fourteen years of age. Enlarged photographs of these sections very graphically depict growth of the mandible and the direction and pattern of eruption of the teeth.

Gottlieb and Orban (1938) pointed out that the dental germ moves occlusalward in every stage of its development at a rate faster than the growth of the bone itself.

Biological:

Sicher (1960) summarizes his viewpoint on tooth eruption by the following:

> "The eruptive movements of a tooth are the effect of differential growth. One speaks of differential growth if two topographically related organs or two parts of an organ are

> are the inevitable consequence of differential growth. The ontogenesis of almost any organ and of the whole embryo proves that differential growth is one of the most important factors of morphogenesis. In the jaws it is the differential growth of tooth and bone which leads to the movements of a tooth."

<u>Radiographical</u>:

Bjork (1955) noted the direction of tooth eruption from the metal implant studies of mandibular development, as a factor concerning the causal relations of third molar impaction. In this same study he noted that apparently there are considerable individual variations in the direction of eruption. An accurate registration of the directional trend of eruption was not possible by the conventional means employed by Bjork at the time this investigation was made.

Differences in direction of eruption between anterior and posterior teeth are known to occur, manifested by changes in the shape of the dental arch and by degree of crowding, and especially pronounced in connection with loss of teeth.

Broadbent (1941) reported on serial studies by means of profile roentgenograms of a Bolton record of a child between the ages of two and three and one-half years. The amount of calcification and path of eruption was observed.

Heredity-Environmental Factors:

Moyers (1958) indicates that:

> "The position of the tooth germ is thought to be determined largely by genetic mechanisms. During the course of eruption, within the alveolus, the tooth's position is affected also by the presence or absence of adjacent teeth, rate of resorption of the primary teeth, early loss of primary teeth, localized pathologic conditions, and by any factors that alter the growth or conformation of the alveolus. Once the oral cavity has been entered, the tooth can be moved by the lip, cheek and tongue muscles, by extraneous objects brought into the mouth, such as thumbs, fingers, pencils, etc., and drift into space created by caries or extractions."

Anthropological:

Atkinson (1940) reported information gathered from sectioned dried skulls concerning the position of the permanent teeth in their crypts during the process of eruption.

CHAPTER III

MATERIALS AND METHODS

MATERIALS USED FOR THIS TECHNIQUE

1. X-ray Manufacturing Corporation of America's Panorex machine was utilized for the radiographic exposures involved during the course of this study.
2. Film used was Eastman Blue Brand.
3. Five by twelve inch cassettes were used fitted with par speed intensifying screens.
4. "Plexiglass," a commercially available plastic (methyl methacrylate polymer), was used for all parts composing the auxiliary positioning device, with the exception of the metal thumb screws which held the component parts of the base of the auxiliary positioning device together.
5. A bite fork means of orientation of the patient was employed. This bite fork was hand made, and plastic was used so radiopacity would not be a major problem. On the external periphery of the bite fork small metal implants were placed exactly one centimeter apart. These were used in calculating

the relative distortion of the tooth shadows recorded on the radiographic film. The described bite fork was attached to a vertically oriented adjustable stabilizing plastic rod.

6. The metallic implants used in the bite fork were .030 by .007 inch round gold soldering discs manufactured by The Julius Aderer Incorporation.

7. The grid used to radiographically document the distortions found on a panoral radiograph was a 1/4 inch galvanized wire screen mesh attached to the external periphery of the above described bite fork.

DESCRIPTION OF METHODS

Technique:

Panoral radiographs were taken of the dried skull shown in the accompanying photographs, employing conventional methods of panoral radiographic techniques. In conjunction with the above, the metallic implanted plastic bite fork positioner was also used. The bite fork was placed in the mouth of the skull so that the metallic implants were in a similar vertical plane as the cusps of the posterior maxillary dentition.

Distances between the metallic implant images were measured on the radiograph and correlated with actual measurements taken directly from the bite fork. The table of distortion values (Table 1) for the metallic implant images relates the quantity of magnified distortion found.

Five exposures were made of the metallic implanted bite fork in place in the auxiliary positioning device rotating the source of radiation from left to right and from right to left. These films were superposed and a photographic print made which establishes that tolerances found employing the Panorex machine were acceptable. (Illustration 6)

Five additional films were exposed in a similar manner as the first five films. This time the auxiliary positioning device was completely disassembled and reassembled before each exposure. These films were superposed and a photographic print was made which documents the acceptability of the auxiliary positioning device for positioning and repositioning the patient. (Illustration 7)

In addition to the metal implant method of studying distortion on the occlusal plane, a wire screen mesh method of studying distortion was employed. A radiograph was made with a 1/4 inch wire screen mesh on the surface of the cassette. The illustration of the photographic print demonstrates the uniformity of the mesh. (Illustration 13) A portion of this same wire screen mesh was adapted to the plastic bite fork at its outer periphery, (the same area as the metallic implants occupied) and was radiographed in position on the auxiliary positioning device using the Panorex machine. The pattern of distortion found can be observed on the photographic print (Illustration 14), and may be compared with the contact print of the wire screen mesh. (Illustration 13)

The radiographic exposure values were:

1. Milliamperes: 5-6

2. Kilovolts: 85-90

3. Time: 32 seconds

Postulated Landmarks:

A method of superpositioning of cephalometric radiographs is described by Thurow (1961). His method has been adapted to this technique using landmarks found on panoral radiographs.

A positive film is made from the first panoral radiograph. A second panoral radiograph is made at predetermined intervals every six months through the mixed dentition period, and annually thereafter from the time the first panoral radiograph was made. The positive film made from the first panoral radiograph is then superposed on the second panoral radiograph using the lower border of the mandible with the curvature of the notch just anterior to the angle as points of reference in two planes of space. On the maxilla, the horizontal palatal surface of the bony palate is used, and the lowest point on the lower border of the orbit as the second point of reference.

Due to increase in size caused by growth each quadrant of the maxillary-mandibular complex must of necessity be assessed individually.

Personal communication with Dr. Harry Sicher (Fall 1961) indicates that no bony landmark is completely stable due to the continual modeling and rebuilding.

CHAPTER IV

RESULTS AND OBSERVATIONS

The panoral radiographs obtained appear as any other panoral radiograph taken with XRM's Panorex, with the exception of the metallic implant images on the radiograph resulting from the spaced metal implants, and the slightly increased vertical dimension due to the thickness of the plastic bite fork.

By the use of this technique, positioning of the patient has been shown to be reproducible within the tolerances shown on the photograph of implant images. (Illustration 6 and 7)

Linear quantification is calculable in all the vertical and horizontal planes found within the scope of a panoral radiograph by the use of the wire screen method of evaluation. (Tables 2 and 3)

By superpositioning of the positive film made from the first panoral radiograph on the second panoral radiograph and using the aforementioned landmarks, one should readily observe the amount of bone growth, direction of bone growth, and changes in position of the hard tissues of the dental oral region of the head.

CHAPTER V

DISCUSSION AND INTERPRETATION OF FINDINGS

Problems encountered:

1. Round metal and plastic rod stock was employed. This does not permit easy return to previously recorded positional readings.

2. Suitable scaling and referencing tables are not an integral part of the Panorex machine and was not a part of the auxiliary positioning device.

3. The Panorex machine was altered by a factory representative of the X-ray Manufacturing Corporation of America during the course of this investigation without the investigator's prior knowledge. This altered the superpositioning procedure for panoral radiographs already exposed.

4. Definition and detail of the incisor region leaves somewhat to be desired on a conventional panoral radiograph exposed by a Panorex machine. The inclusion of the upright plastic rod through which x-rays must pass before reaching the incisor area of the film tended to decrease even more the desired

definition and detail of this area.

5. The commercially available Panorex machine in its entirety has been designed as a survey type machine and not as a research tool.

Suggested improvements:

1. Utilization of rectangular stock, both metal and plastic, would insure easy return to previously recorded readings.

2. Equipment design should include somewhat closer tolerances throughout to minimize error.

3. The chin orientation device should be positioned to a more suitable mean angle to permit an easier horizontal orientation of the occlusal plane of the patient.

4. A shorter exposure time would help eliminate positional fatigue of the patient, hence reduce movement of the patient and consequent fuzziness of the final product on the panoral radiograph.

5. Camming of the exposure governing devices of the equipment to permit additional penetration of the incisor region; this would increase definition and detail on the incisor area of the radiograph.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A technique which includes the utilization of the previously described auxiliary positioning device and the aforementioned anatomical landmarks has been devised which provides a method of positively repositioning a patient for subsequent panoral radiographs.

A large amount of distortion is present on each film. This distortion is reproducible segmentally, and quadrant superpositioning is therefore possible.

Linear quantification of a given individual is possible in vertical planes and in horizontal planes found within the boundaries of a panoral radiograph. This is subject to the reliability of the anatomical landmarks.

This investigation provides a scientific method for documenting radiographic evidence concerning amount of growth, direction of growth, and changes in position of the hard tissues of the oral region due to growth by the use of the herein described technique.

This technique is by no means in its final form. Further effort in research is indicated concerning the reliability of the landmarks mentioned, and in perfecting the auxiliary apparatus used for orientation of the subjects for panoral radiographic studies.

TABLES

TABLE 1

DISTORTION BETWEEN METAL IMPLANTS

Measurement taken directly from bitefork:

Aggregate distance of four metallic implants . . . . . . 30 mm.

Measurement taken from photographic print of five superposed radiographs:

Aggregate distance of four metallic implant shadows . . 39 mm.

Percent of magnified distortion found 30%

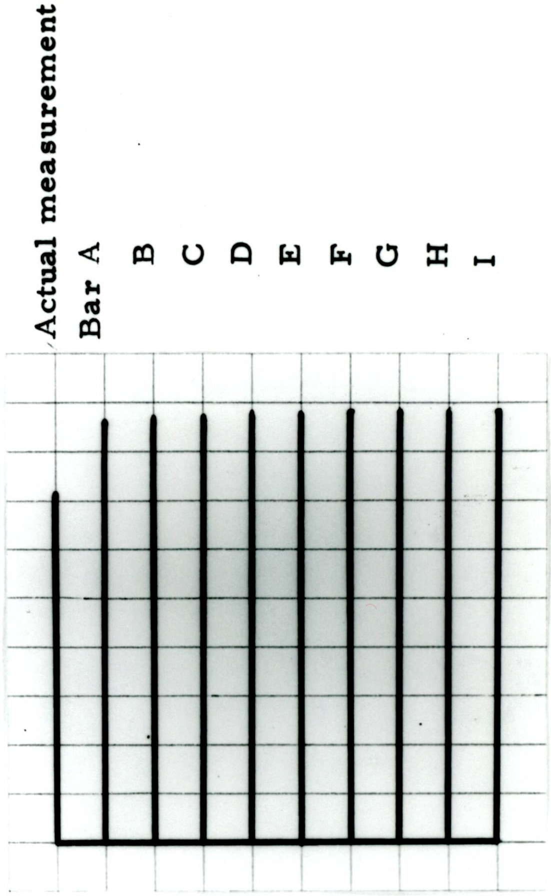

TABLE 2

VERTICAL DISTORTION RANGE

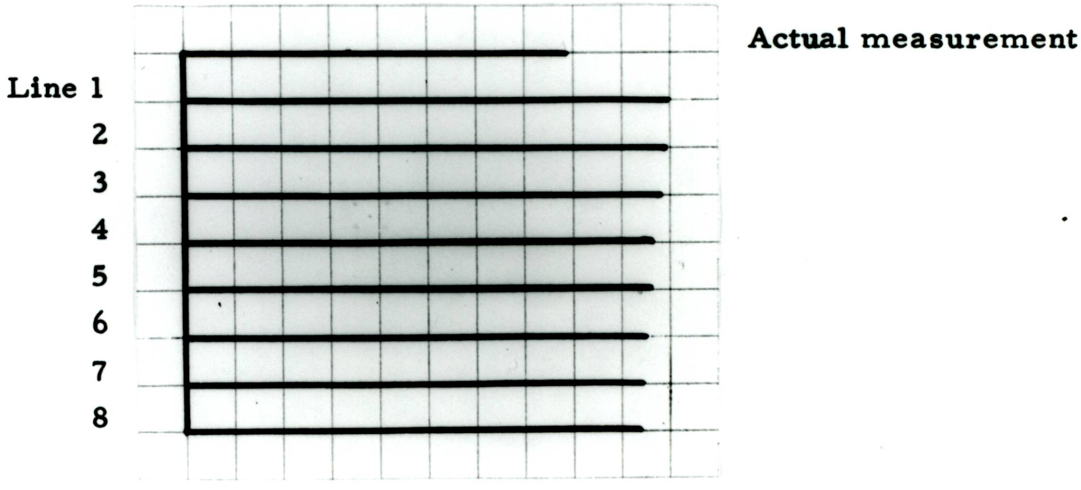

TABLE 3

HORIZONTAL DISTORTION RANGE

FOR BOTH TABLES 2 AND 3 ACTUAL MEASUREMENTS WERE TAKEN FROM ILLUSTRATION 13, BAR AND LINE MEASUREMENTS WERE TAKEN FROM ILLUSTRATION 14

ILLUSTRATIONS

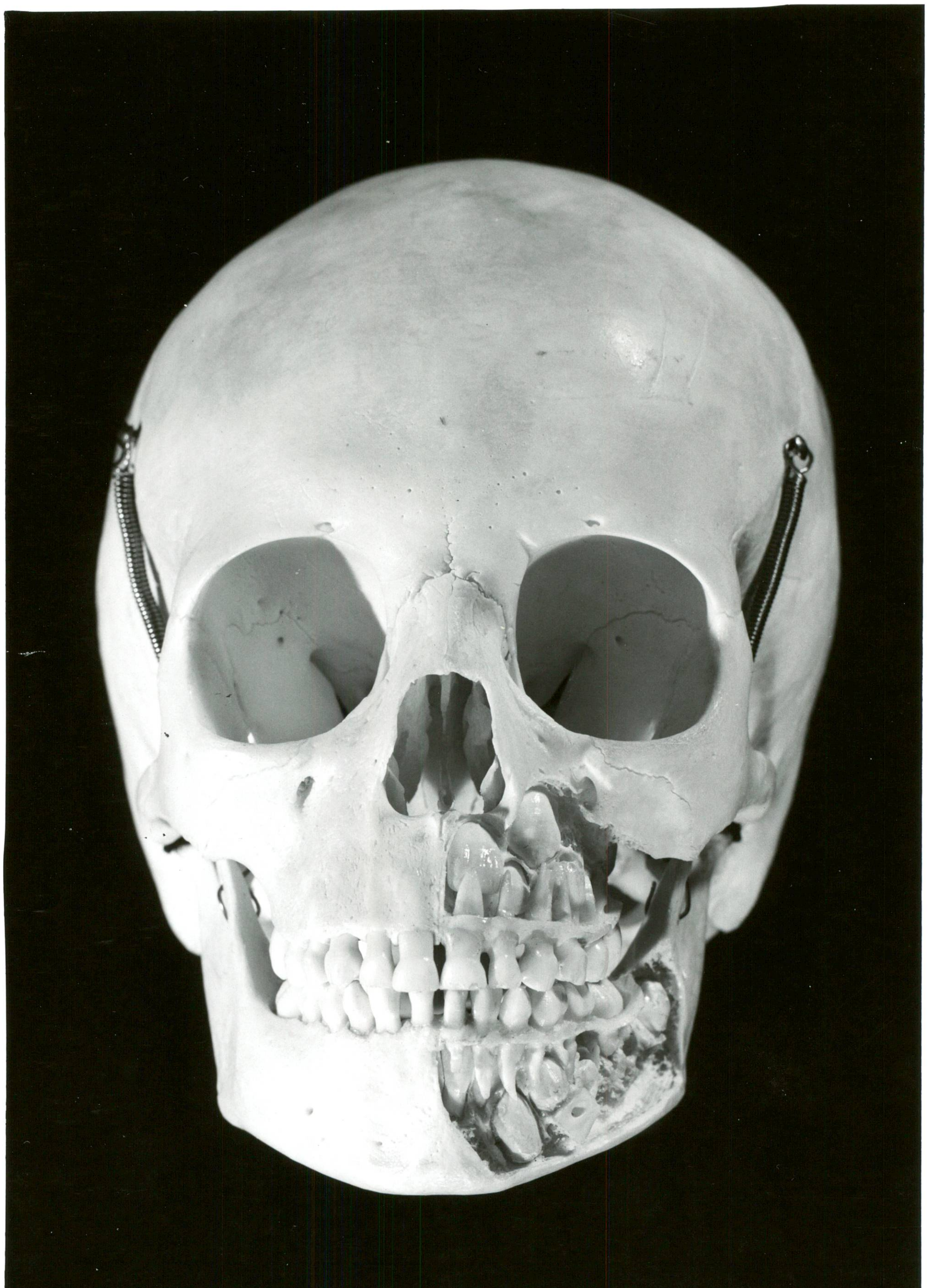

ILLUSTRATION 1

ANTERIOR VIEW OF DRIED SKULL

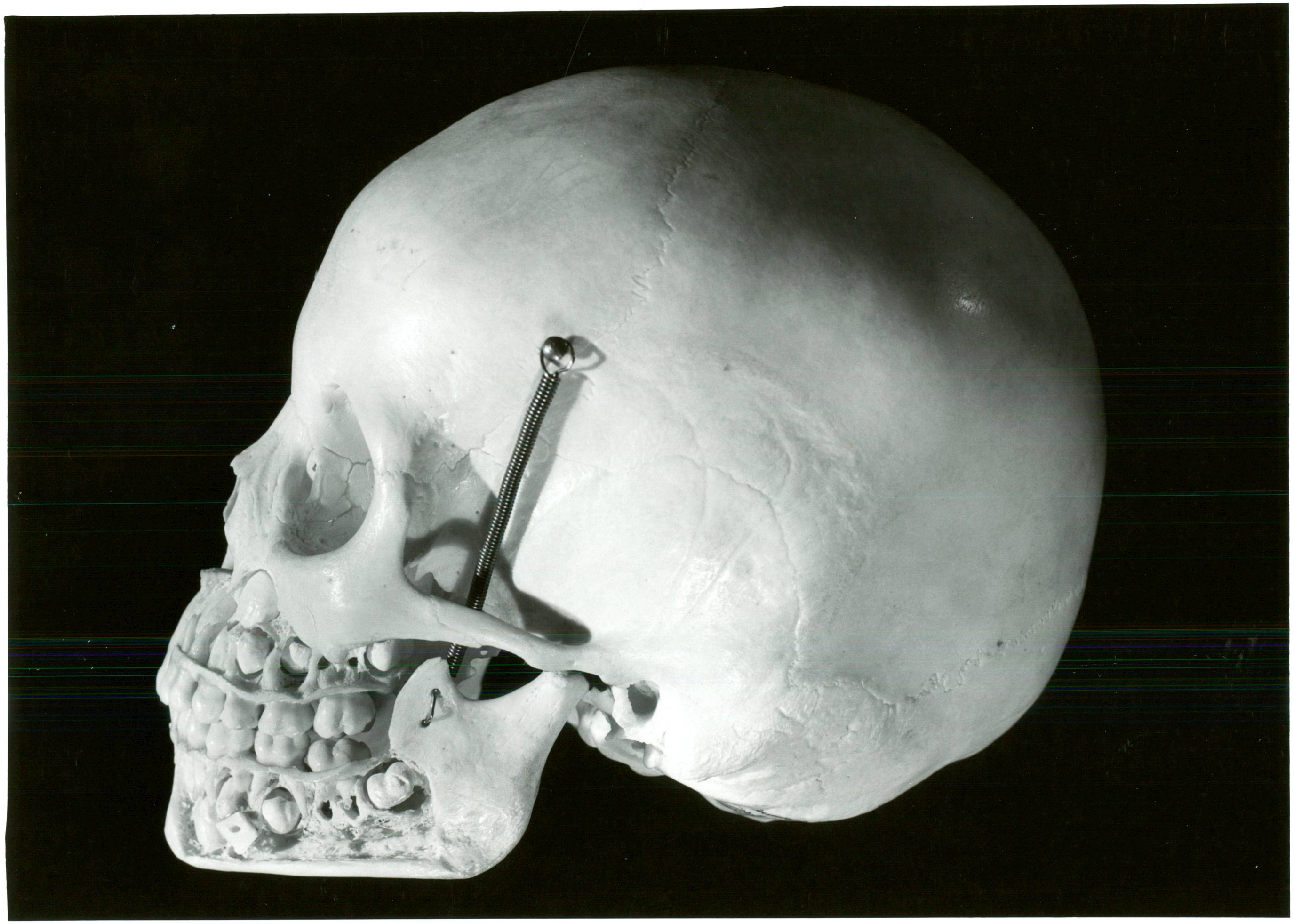

ILLUSTRATION 2

LATERAL VIEW OF DRIED SKULL

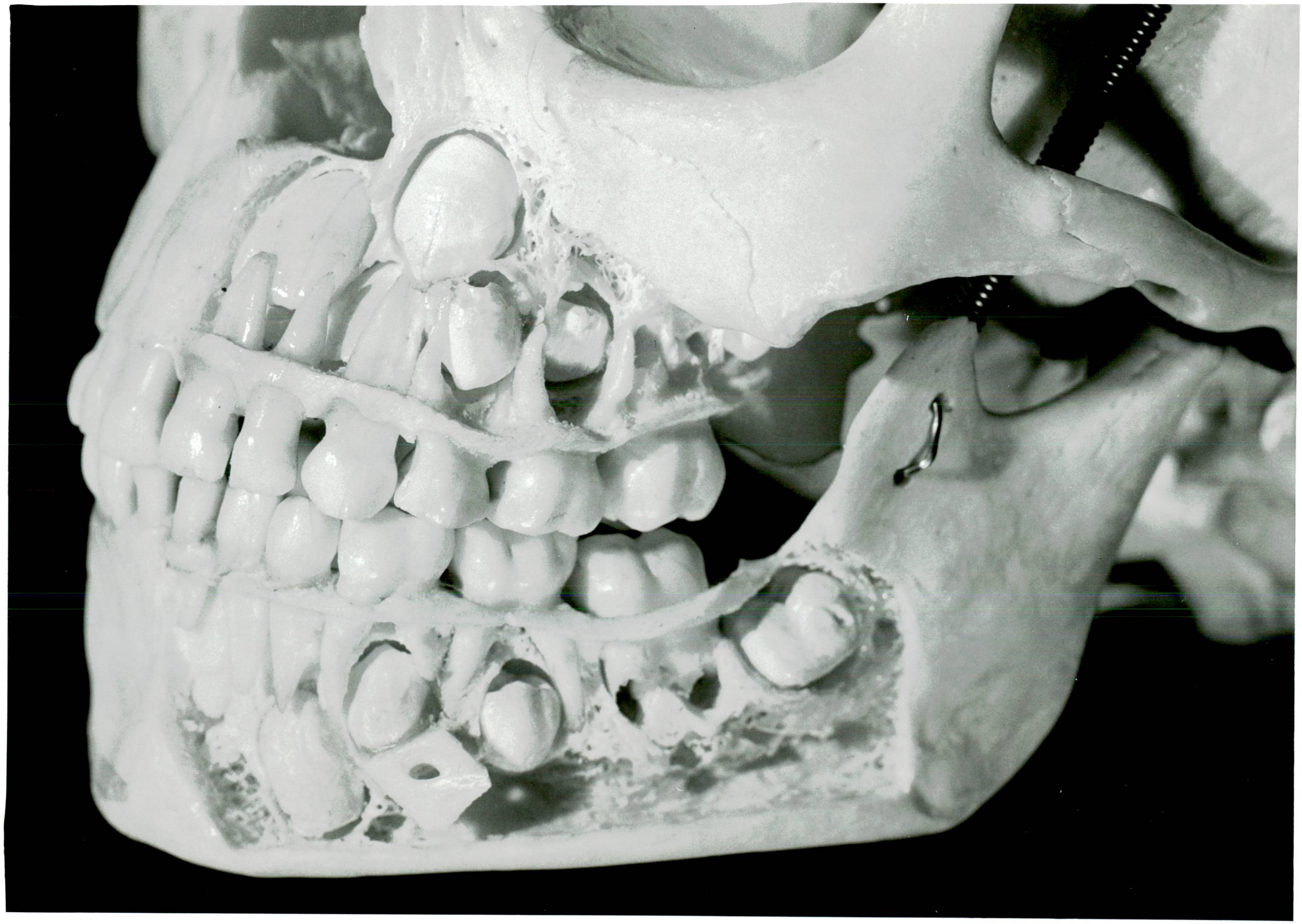

ILLUSTRATION 3

OBLIQUE VIEW OF DISSECTED AREA, CLOSE UP

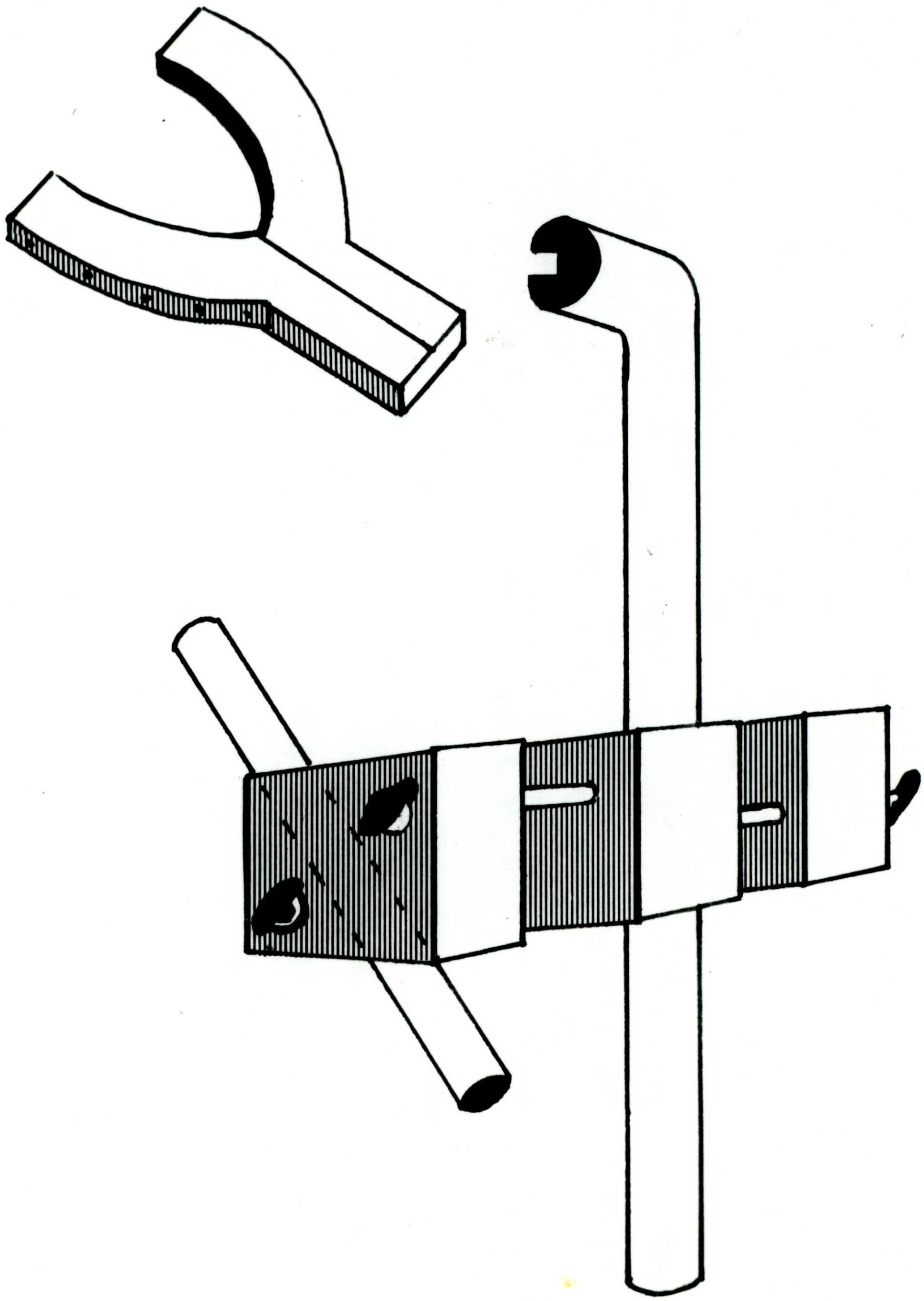

ILLUSTRATION 4

PHOTOGRAPH OF DRAWING OF AUXILIARY POSITIONING DEVICE, UNASSEMBLED

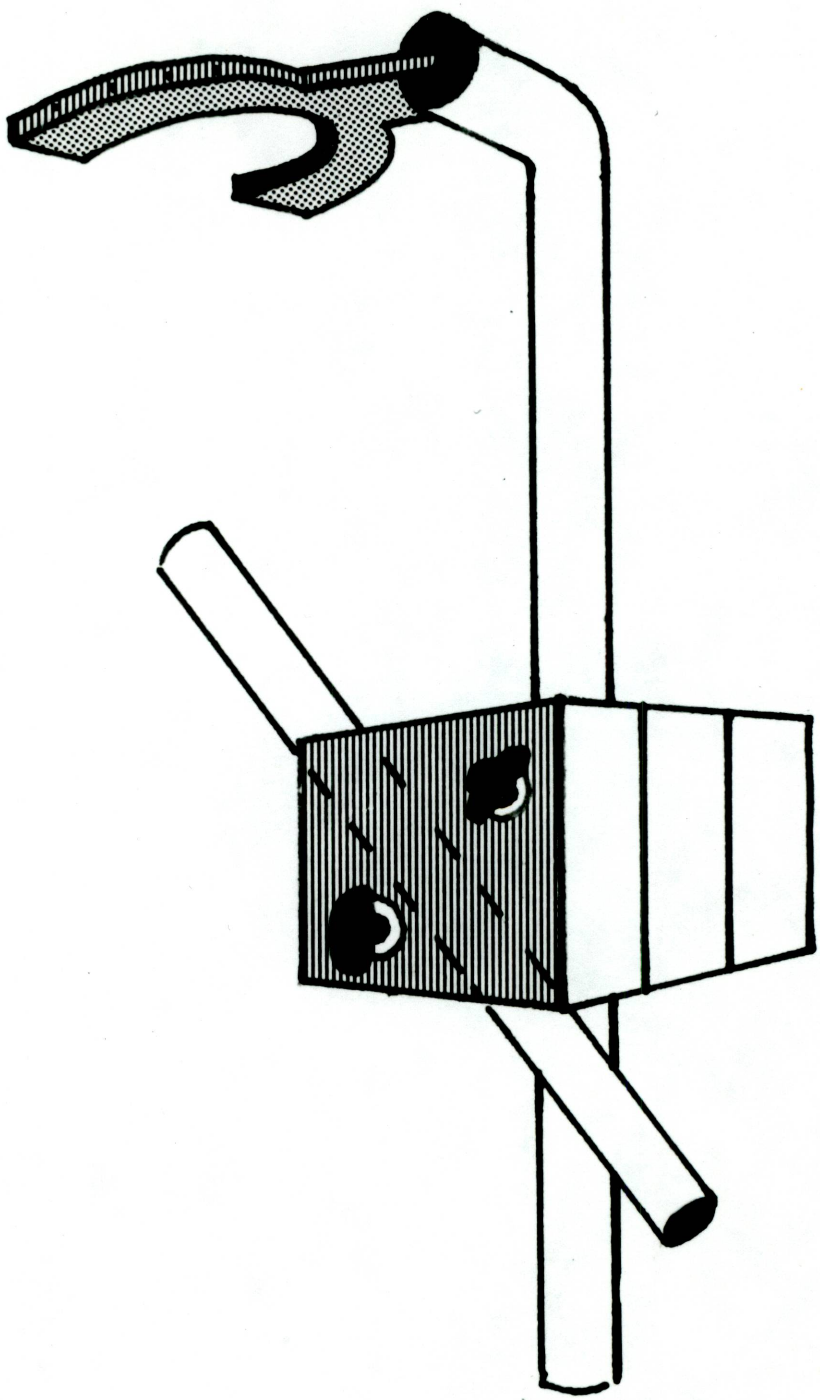

ILLUSTRATION 5

PHOTOGRAPH OF DRAWING OF AUXILIARY POSITIONING DEVICE, ASSEMBLED

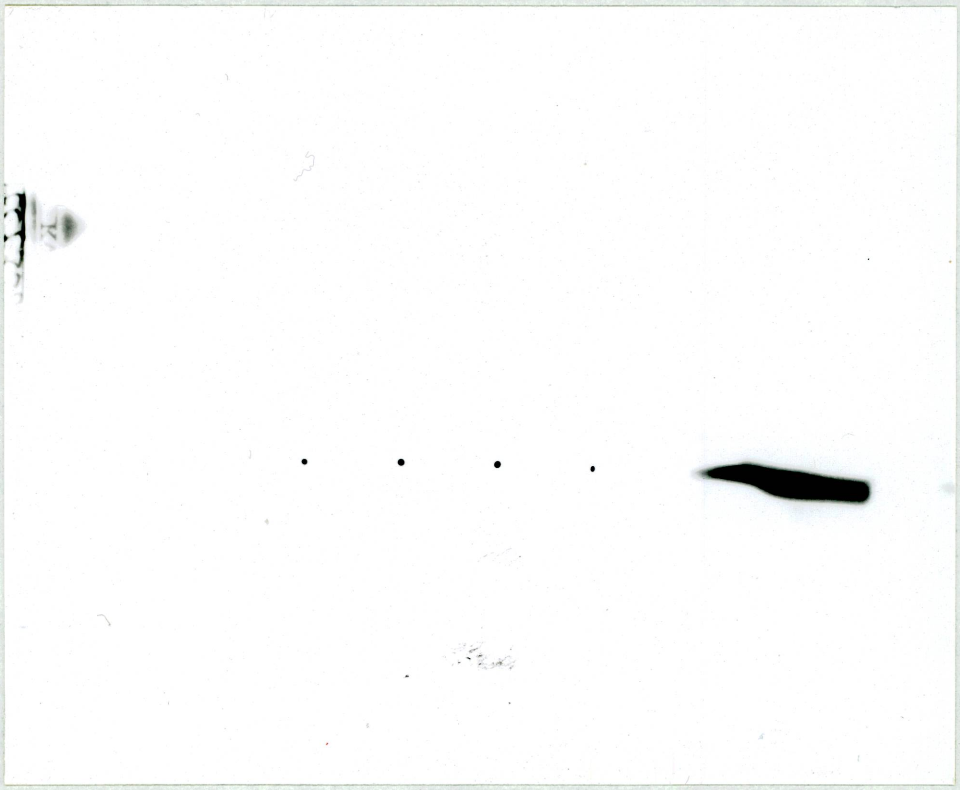

ILLUSTRATION 6

PHOTOGRAPHIC PRINT OF METALLIC IMPLANT IMAGES
AFTER SUPERPOSITIONING OF FIVE
RADIOGRAPHIC EXPOSURES

THE AUXILIARY DEVICE WAS NOT DISASSEMBLED
DURING THIS SERIES OF EXPOSURES

ILLUSTRATION 7

PHOTOGRAPHIC PRINT OF METALLIC IMPLANT IMAGES
AFTER SUPERPOSITIONING OF FIVE
RADIOGRAPHIC EXPOSURES

THE AUXILIARY DEVICE WAS COMPLETELY
DISASSEMBLED AND REASSEMBLED
BEFORE EACH EXPOSURE

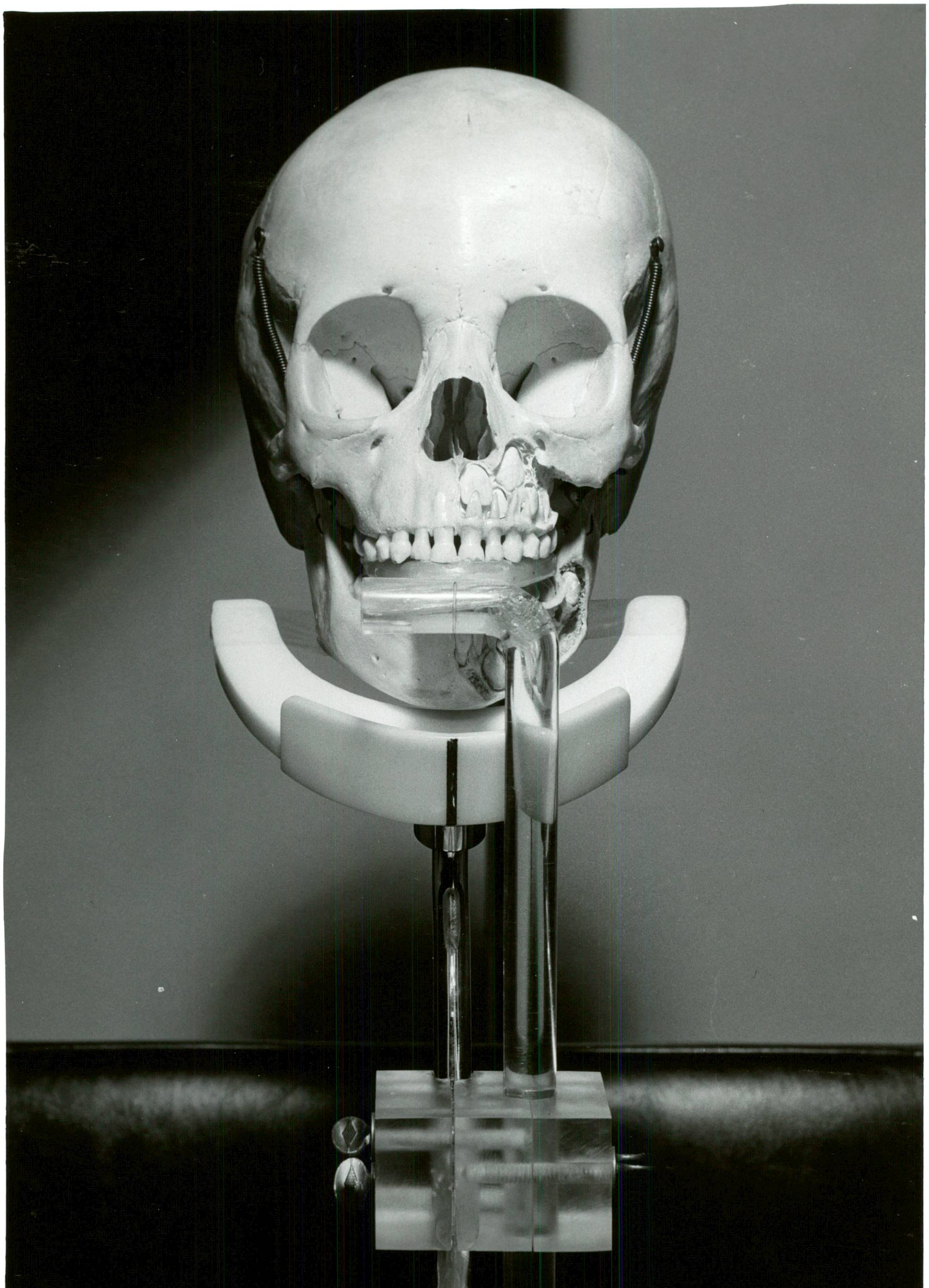

ILLUSTRATION 8

AUXILIARY POSITIONING DEVICE WITH DRIED SKULL
IN RADIOGRAPHIC POSITION

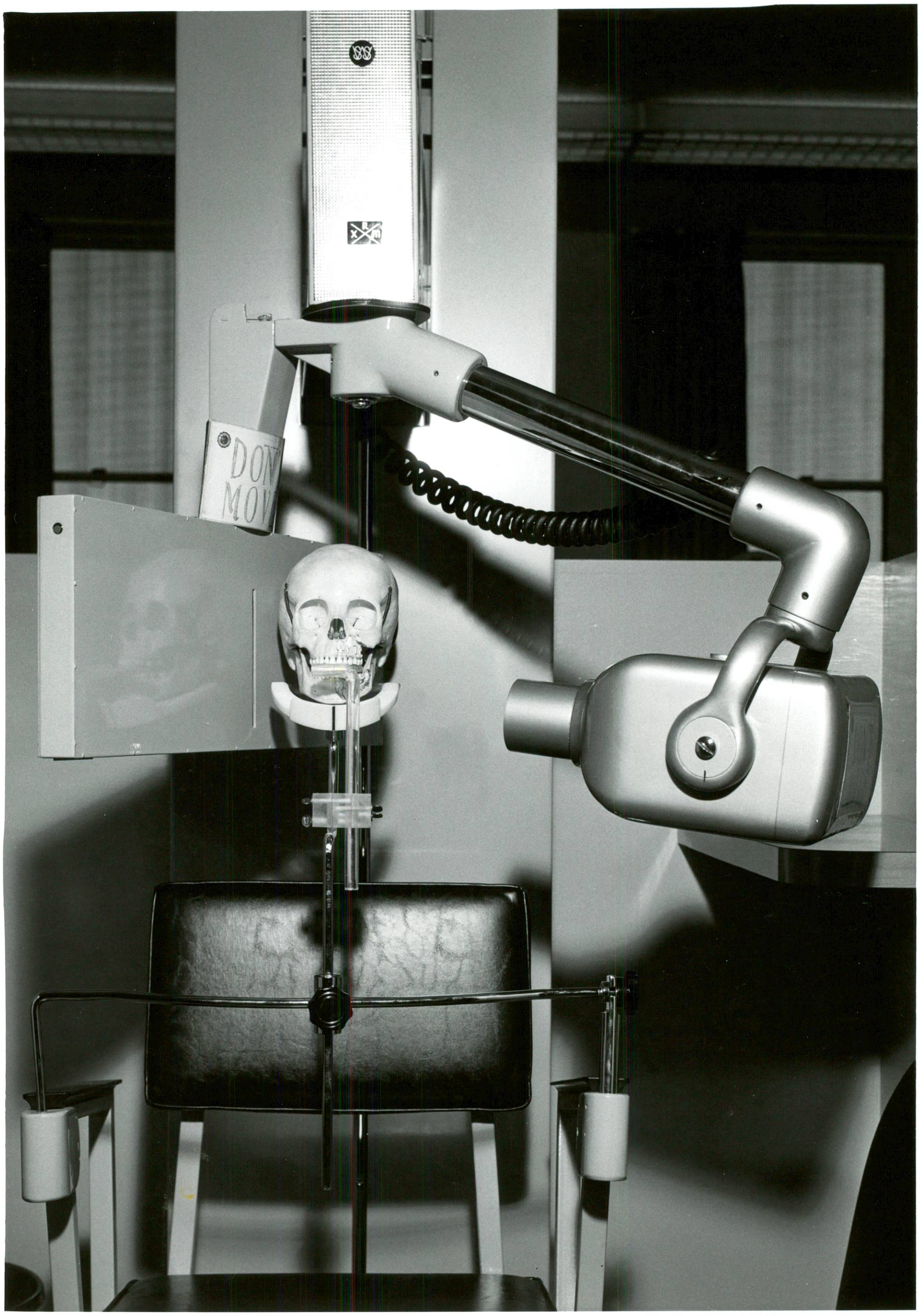

ILLUSTRATION 9

XRM PANOREX MACHINE WITH POSITIONING DEVICE
IN PLACE AND SKULL IN RADIOGRAPHIC POSITION

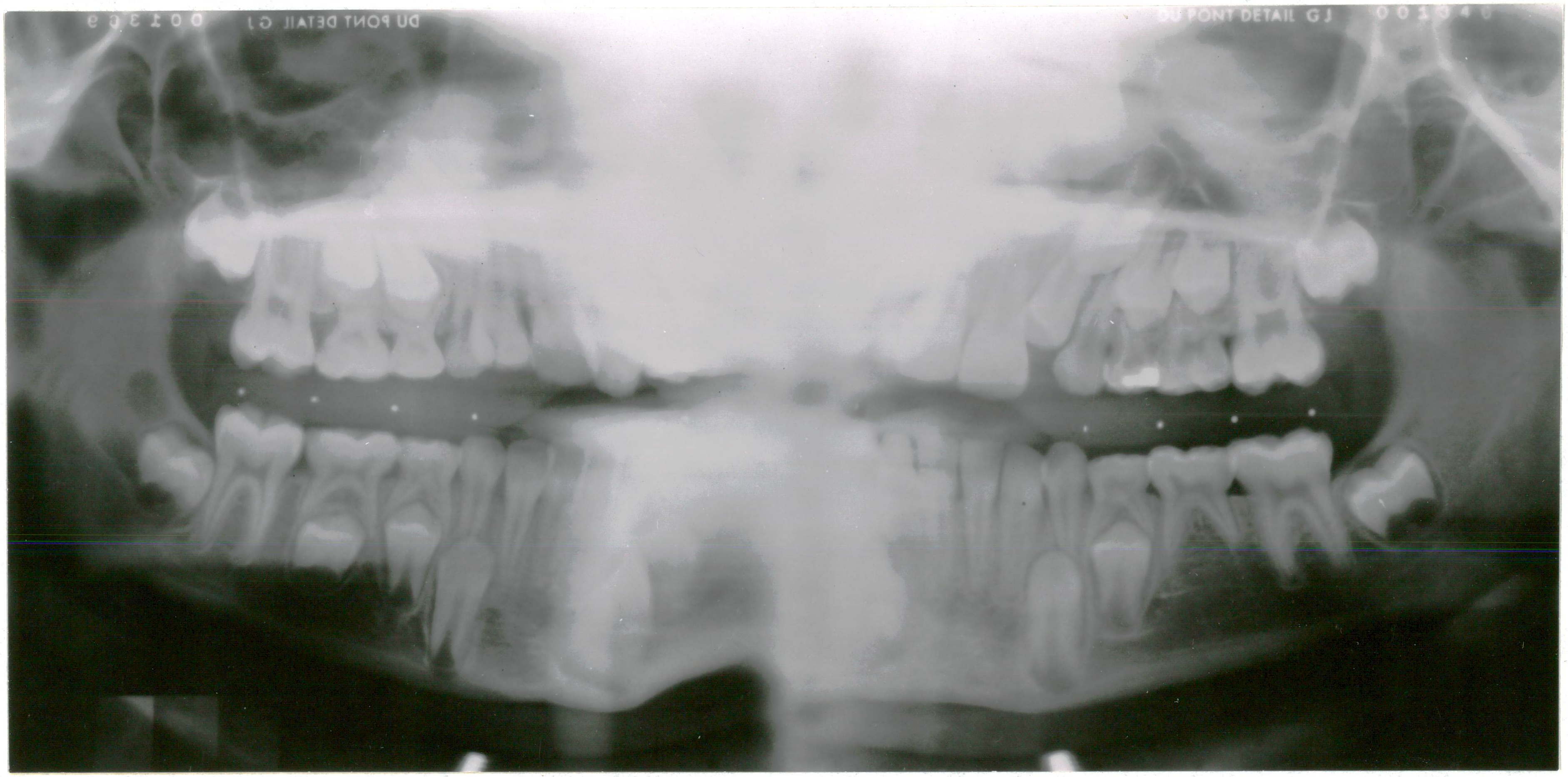

ILLUSTRATION 10

PANORAL RADIOGRAPH WITH METALLIC IMPLANT IMAGES -- CLINIC PATIENT

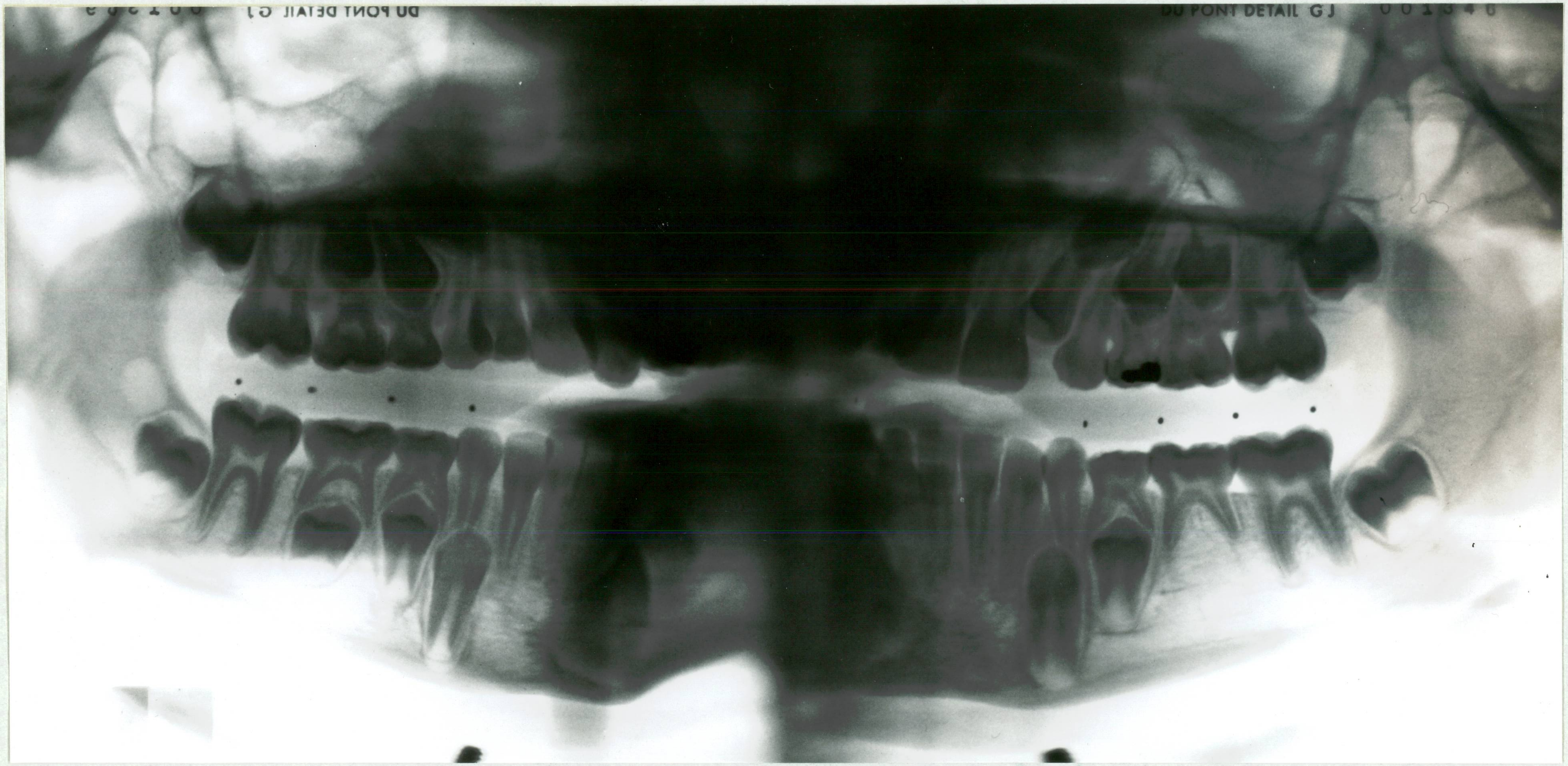

ILLUSTRATION 11

PANORAL RADIOGRAPH (POSITIVE) WITH METALLIC IMPLANT IMAGES -- CLINIC PATIENT

ILLUSTRATION 12

SUPERPOSITION OF NEGATIVE AND POSITIVE CEPHALOMETRIC RADIOGRAPHS OF A SUBJECT TAKEN AT A SIX YEAR INTERVAL, NEGATIVE TAKEN AT 17 YEARS 6 MONTHS, POSITIVE TAKEN AT 11 YEARS 6 MONTHS

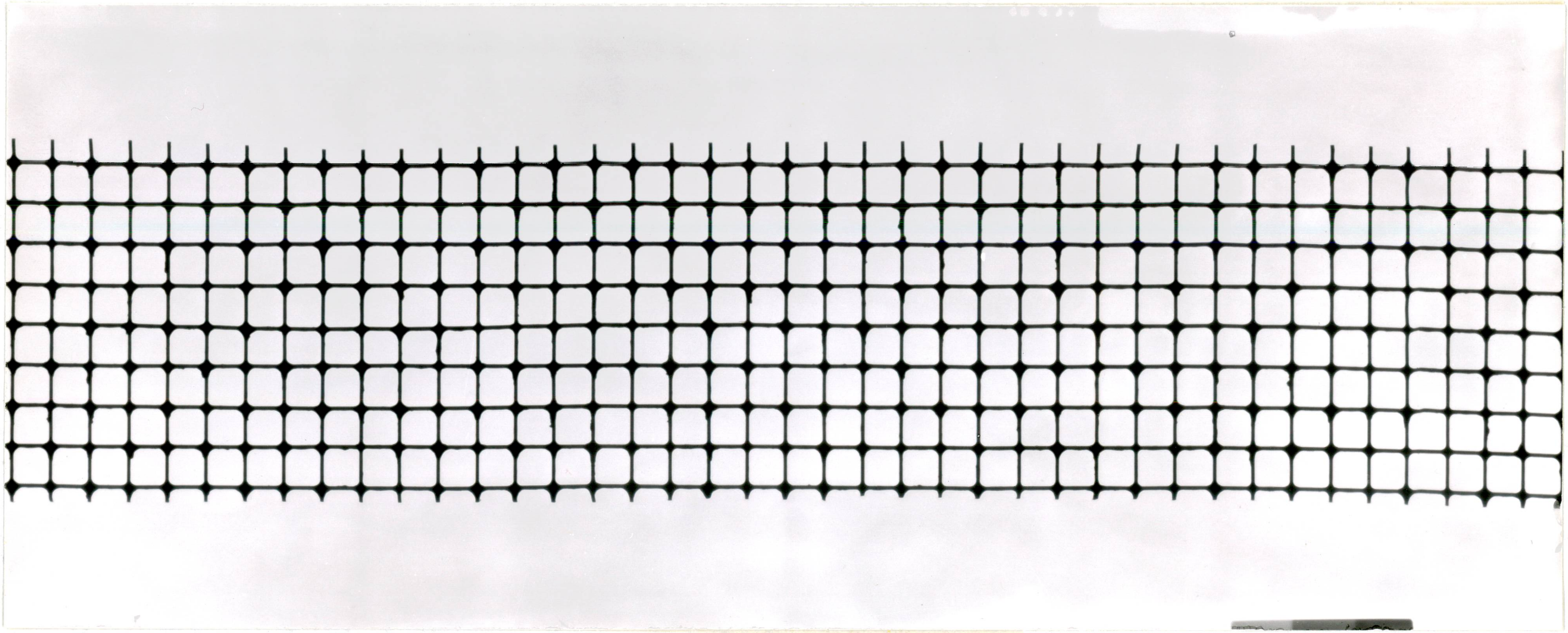

ILLUSTRATION 13

CONTACT PRINT OF WIRE SCREEN MESH

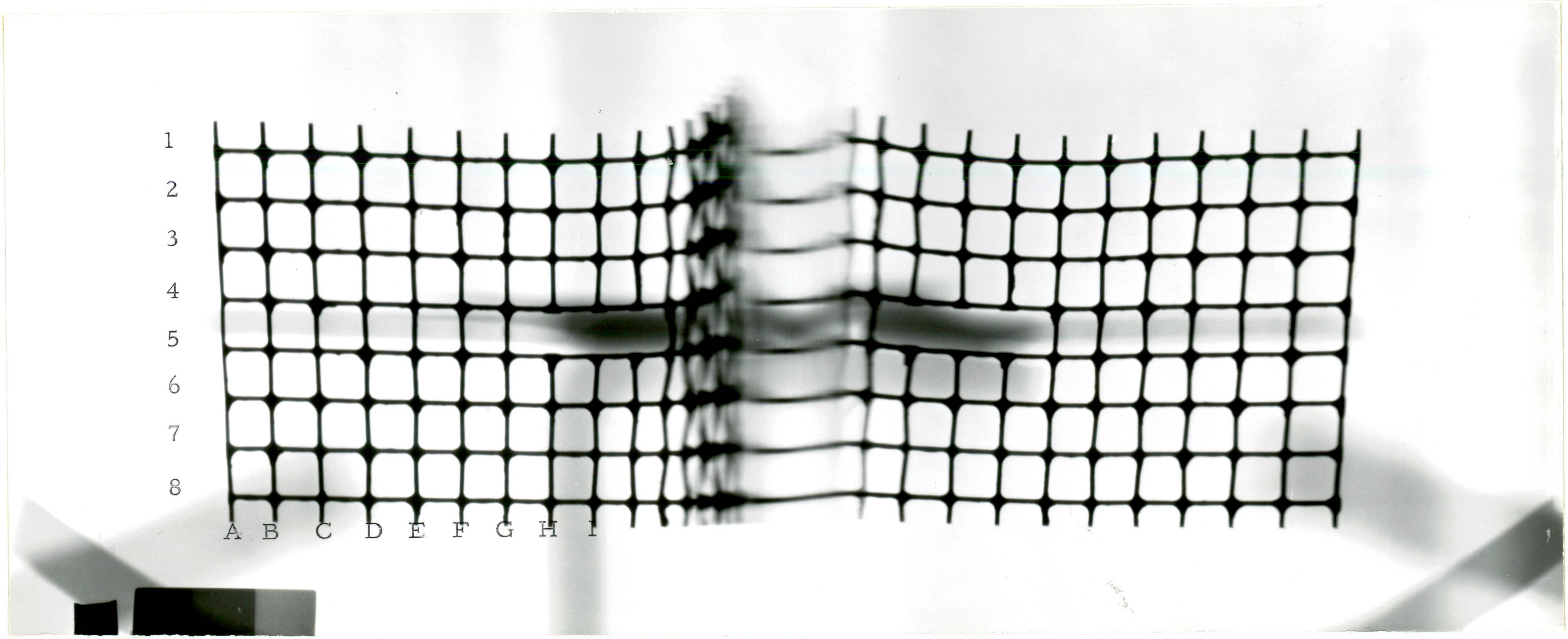

ILLUSTRATION 14

CONTACT PRINT OF THE WIRE SCREEN MESH RADIOGRAPHED IN THE DENTAL AREA UTILIZING THE AUXILIARY POSITIONING DEVICE

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LOMA LINDA UNIVERSITY

School of Graduate Studies

A TECHNIQUE FOR STUDYING THE SPACIAL RELATIONSHIP OF ORAL HARD TISSUES UTILIZING PANORAL RADIOGRAPHY

by

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An Abstract of a Thesis

in Partial Fulfillment of the Requirements

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in the Field of Orthodontics

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ABSTRACT

Although panoral radiography employing various techniques has been described in the literature since 1949, no information is available relative to its application in quantification of positional change of the hard tissues of the oral region.

An assessment of the radiographic equipment available to this investigator for quantification studies seemed imperative before embarking on this research.

In order to establish a standard, five exposures were made on radiographic film rotating the source of radiation from left to right and from right to left. These films were superposed and it was established that the tolerances found using the Panorex machine were within an acceptable range.

Five additional films were exposed in a manner similar for establishing an acceptable accuracy of the Panorex machine. This time the auxiliary positioning device was completely disassembled and reassembled before each exposure. These films were superposed and photographic evidence documents the acceptability of the auxiliary device

for positioning the patient.

A contact exposure was made using a wire screen. This same screen material was used on the same vertical plane as the cusps of the upper posterior teeth. Calculations were made showing the relative distortions in given dental areas.

Since repositioning of the patient is possible, and since distortion can be duplicated, it is possible to quantify the distortion found.

The following is a brief summary of the more significant findings of this investigation:

1. The Panorex machine was found to be acceptable for this investigation within certain tolerances.

2. With the use of the auxiliary positioning device patients can be repositioned for subsequent panoral radiographs suitable for superpositioning.

3. Distortion in varying degrees is present on the panoral radiographs, and this distortion can be duplicated.

4. Since the distortion is duplicatible, superpositioning quadrant by quadrant is possible.

6. The distortion found on panoral radiographs therefore is: predictable, reproducible, and measurable.