PORTABLE SPOT-FOCUSING APPARATUS FOR RADIOGRAPHY

Fig. 4

Fig. 7
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This invention relates to an apparatus to be used in conjunction with radiology of the human body. The invention provides a novel and useful adjunct to radiography of the temporomandibular joint, the ear, and other areas of the head; and to various other parts of the body. Its novel features include provisions for spot-focusing of the central X-ray beam upon a specific area to be studied so that X-ray radiation is markedly diminished, secondary rays eliminated and a superior focused radiograph may be made by a simplified method and multiple duplicate radiographs may be made from fixed angles of a specific area in various postures at the same or at various times. This apparatus is portable so that it may readily be placed in desirable positions in relation to an operating table, dental chair or bed, and can be removed and replaced as needed. This apparatus includes a shielded X-ray focusing tube and a shielded sleeve for retaining the X-ray film which provides for multiple radiographs on a single film by exposing only selected areas of the film to the focused X-rays.

This apparatus is provided with a series of separate removable guide-bars or arms, each of which is arranged to fit securely and in fixed relationship with the shielded sleeve, and thus with the X-ray film in the sleeve. These arms each extend at a 90° angle in the horizontal plane intersecting the X-ray film such that the angle of orientation of the vertical plane such as 0°, 10°, 20°, 30° above and below the horizon. Thus, the X-ray stream always strikes the film at right angles in the horizontal plane, and at various fixed angles in the vertical plane. These guide-bars are arranged to maintain the shielded tube at similar angles in relation to the shielded sleeves.

In temporomandibular joint-bar radiography the area to be X-rayed has a radius of about one inch. Radiographic techniques for lateral studies require that the film be in contact with the side of the head of the joint-bar area to be radiographed and that the X-ray be directed from the opposite side of the head preferably at an angle of 20° or 30° above horizontal. For maximum results the center of the rays that are emitted by the X-ray machine should pass through the center of this one-inch radius area and strike the center of the exposed portion of the film. The complexity and difficulty in accomplishing this important requirement is shown by the fact that at present the operator must guess or judge the direction and location of the X-ray in relation to the area to be radiographed and exposed portion of the film and/or place the source of the ray dangerously close to the head. My apparatus eliminates all the necessity for guess or judgment by fixing the angle and direction of the ray in a fixed, spot-focus on the area to be radiographed and on the exposed portion of the film. Thus, with a fixed 20° angle guidebar and the movable arm and tube which is fixed to the arm so that it is parallel with the guidebar or extension arm in all movable relationships toward or away from the film, it is possible to spot focus a given area. The significance and application of these features of my invention are shown by the fact that when a spot or mark that is placed with ink or crayon on the temporomandibular joint or other part of the patient to be radiographed, is placed in contact with the centering mark or target area on the window of the film-retaining sleeve, which will be described more fully hereinafter, the ray from the X-ray machine is directed through the tube and through the head so that it passes through the center of the temporomandibular joint-ea area and is sharply focused on the center of the exposed portion of the film. In addition, my apparatus reduces the exposure of the person to minimum radiation since only the exact area to be radiographed is exposed to the focused X-rays and also by focusing the X-ray beam no other parts of the patient are radiated.

Another feature of my invention is a provision in the sleeve that holds the film that enables multiple X-rays on segments of the same film with the head or other portion of the body in the same or different spot-focused postures in order to compare different angled views or the same angle views from different aspects for diagnostic purposes or to check the progress of treatment as in changing the bite in dentistry, or reducing or pinning fractured bones and dislocated joints in surgery and orthopedics. Having explained some of the new features and advantageous uses of my invention, further advantages and details will be apparent from the following description and accompanying drawing, wherein

Figure 1 is a side elevational view of my apparatus suitable for use in radiography of temporomandibular joint-ea area,

Figure 2 is an enlarged front view of the cassette support partly in section,

Figure 3 is a sectional view taken on line 3—3 of Figure 2,

Figure 4 is an exploded perspective view of the elements for retaining the cassette on the supporting arm,

Figure 5 is a diagrammatic side view of the apparatus shown in Figure 1 to illustrate the X-ray beam focused on a predetermined area of the X-ray film,

Figure 6 is a diagrammatic view of the apparatus provided with a supporting arm at a different angle from that shown in Figure 5 for focusing the X-ray beam on a predetermined area of the X-ray film, and

Figure 7 is a diagrammatic perspective view showing the angular relations of the focused X-ray beam in respect to the face plane of the X-ray film exposed to the X-ray beam.

Referring to Figure 1, the apparatus comprises a stand 10 which is provided with casters 11 to permit the stand to be moved to any desired location. The stand is provided with a tubular upright stand 14 which is adapted to slidably retain in its hollow socket an adjustable post 17. A spring 15 is provided at the bottom of the socket 14 for normally urging the post 17 upwardly. A cock screw 16 is provided at the upper end of the stand 14 which is adapted to retain the post 17 at any suitable height. The upper end of post 17 is provided with an integral horizontal extension arm 18 which terminates in a T-joint 25. T-joint 25 is provided with a vertical bore 25a, as shown in Figure 4, which receives a rotatable post 26 integral with base 26b retained on the upper wall portion 29 of a rectangular sleeve 30. A washer 27 is positioned on the upper face of the T-joint 25 and a supporting member 42 is positioned on the wash bolt 27 in the relation shown in Figure 4.

Supporting member 42 is formed of a circular-shaped base portion 42d which is integral with an upright square-shaped post 42c. The base 42d is provided with an internal axial round bore 42b which is adapted to receive the upper end of post 26. The upper end of post 26 is provided with a hole 26a extending therethrough to receive locking pin 28. The base 42d is also pro-
vided with a hole or bore 42c for receiving the locking pin 28. The elements previously described are assembled by inserting post 26 in the bore 25a of T-joint 25 so as to extend therethrough. The washer 27 is then positioned on the T-joint 25 and the supporting member is then positioned so as to receive the upper end of post 26 and the round bore 42a. The holes 26a and 42a are aligned and locking pin 28 is inserted in the aligned holes. It will be apparent from this construction that the post 26 is rotatable in relation to the T-joint together with the support 42 which are locked together by pin 28. The guide-bar 40 always extends at right angles to the sleeve and is used in conjunction with the horizontal plane and can rotate with it around the axis center of the sleeve 30.

The rectangular sleeve 30 is formed of stainless steel or other suitable material and comprises a front wall 31, a rear wall 35, a top wall 29 and bottom wall 38. The ends of the sleeve are open to slideably receive therein a conventional X-ray film cassette 5 containing an X-ray film. The inner faces of the sleeve 30 are lined with lead sheet 32 for shielding against X-rays. The lower medial portion of front wall 31 of the sleeve 30 is cut out to provide a rectangular opening indicated by numeral 33. This opening is preferably dimensioned to be other than sensitive with 1/4 of the area of an X-ray film to be placed in the sleeve, although it may be 1/4, 1/2 or other depending upon the size of the film and of the part to be radiographed. A sheet of transparent plastic material 34, such as "Lucite," of substantially the same area as the front wall 31 of the sleeve is attached to the outer face of the front wall as by pins 34a at the corners thereof. A transparent window is thus provided in front wall 31. The window is provided with crosslines or other indicia to provide a fixed central target 39 for impingement by a focused beam of X-rays. The rear wall 35 of the sleeve is cut out to provide a rectangular opening 36 positioned oppositely of the front transparent window. This opening is substantially of the same width as the front window and of a length substantially the height of the rear wall 35. A transparent window may be provided if desired over the opening in the rear wall 35 having intersecting center lines to serve as a target for a focused X-ray beam.

The window opening in the front wall of the sleeve 30 is so arranged that its dimension is preferably 1/4 of the width of the X-ray film cassette which is fit into the sleeve and is situated in the middle of the lower half of the sleeve. Thus, the overall inner dimensions of the sleeve are slightly more than 1 and 1/2 the width of the X-ray film cassette and the height of the cassette to provide a loose-fitting fit of the X-ray film cassette in the sleeve and to expose 1/4 of the film in the cassette for each X-ray exposure, thus providing for four radiographs on one film. The rear window provides for two radiographs on one film when this window is exposed to an X-ray stream, and also provides a view of the centering mark on the front window in relation to the target mark or landmark on or of the part to be radiographed. The upper square post 42a, previously described, is adapted to removably receive the square bore 40b provided in hub 40a integral with arm or guide-bar 40, as shown in Figures 1 and 4. The longitudinal axis of guide-bar 40 may subtend at a selected fixed angle, for example 20° from the horizontal, as shown in Figure 1. If desired, guide-bar 40 may be replaced by a similar bar subtending at any other desired angle, such as 10°, 30° or 40° from the horizontal. It will also be apparent that guide-bar 40 may be reversely positioned from the position shown in Figure 1 so that it extends 20° or other predetermined angle above the horizontal plane.

A slideable hanger arm 45 is carried on guide-bar 40 and is adapted to be positioned at any desired location and retained on the guide-bar by means of a fastening screw 46. The arm 45 carries an open-ended X-ray focusing tube 60 which is so attached that it remains parallel with the guide-bar in every position of adjustment along the guide-bar. Tube 60 is lead lined and may be provided with rubber rings or other yieldable material for cushioning the end 60a against the patient 50, as shown in Figure 1, and for removably receiving at the opposite end 60b, the cone or tube 65 of an X-ray machine. The shielded tube 60 may be of any suitable cross-sectional contour, such as circular, rectangular or triangular and of such dimensions as to emit an X-ray stream of the minimum cross-sectional area necessary for obtaining the desired radiograph of a specific portion of a patient's body with the minimum exposure to radiation. If desired, a removable lead or other solidly tured diaphragm may be positioned adjacent the end 60c of the tube so that only the exact minimum X-ray stream will be emitted through the aperture of predetermined size and contour. It will be apparent that the longitudinal axis of the tube 60 will be parallel to the longitudinal axis of the guide-bar 40, as shown in Figure 5, and therefore the stream of X-rays emitted by the cone 65 of the X-ray machine 70 will be directed always at the angle of the guide-bar toward the same target spot 39 on sleeve 30. The X-rays will also always be focused on the center mark 39 in the front transparent window. In the Figures 1 to 7 the central stream axis A of the X-ray beam will always be directed at an angle of 90° to the horizontal plane intersecting the X-ray film surface and that the degree of angulation 8 in the vertical plane A' intersecting the X-ray film can be varied depending upon the angle of the guide-bar 40 which is used. As previously explained, different removable guide-bars 40 may be provided extending at any predetermined angle from the horizontal. Thus, as shown in Figure 5, it extends at an angle of 20° from the horizontal, and in Figure 6 it extends at an angle of 10° from the horizontal. In the Figures 1 to 7 the vertical height of the hub 40a of guide-bar 40 is varied so that the central axis of the X-ray beam is always directed at the target area 39. Thus, as shown in Figure 6, the hub 100a of guide-bar 100 is shorter in height than the hub 40a of guide-bar 40 shown in Figure 5 to the extent that the central axis A' of the X-ray beam will strike the target 39. Thus, any part of the body of a patient upon which a spot is previously marked with ink or crayon and said inked spot is placed against mark 39 of the window will be centrally radiographed with maximum focus of the X-ray beam. The cassette sleeve behind the window. It will also be apparent that the central axis of the X-ray beam will pass through the central part of the area of the patient's body which is to be radiographed and at the same time will always strike the target area 39 on the film at right angles to the horizontal plane intersecting the X-ray film surface.

My present invention particularly fulfills the requirement of temporomandibular joint radiography by use of the apparatus described which focuses the X-ray from the opposite side of the head of the patient directly through the center of the joint that is to be studied. This arrangement provides for the X-ray which enters the tube 60 at any distance on the opposite side of the head 50 of the patient from the sleeve 30 to be focused on target 39 of the transparent window in the lower half of the center of the sleeve 30, against which is placed the joint to be radiographed. The tube 60 is angled against the window so that the temporomandibular joint to be radiographed is in contact with the target 39. The tube 60 is then moved along guide-bar 40 until its soft rubber end 60b is against the opposite side of the head 50 of the patient. Its contact with the head 50 of the patient holds the head and joint in tensioned position. A cassette 5 holding the X-ray film is then placed into the sleeve 30 and the X-ray cone 65 is brought to and inserted in the open end 60b of the tube 60. The radiograph is then taken. For multiple radiographs the
head and joint area are maintained. One view may be with the teeth in occlusion, another with the bite opened. The inserted X-ray film cassette 5 is so arranged that ¼ of the X-ray film is exposed for each radiograph while the remaining ¾ of the film and cassette are protected from the X-ray stream by the lead lining 32 of the sleeve 30. The X-ray film cassette 5 is moved forward to expose the second quarter of the film for the second or opened view of the patient's joint. The head of the patient is then released and turned to place the other side and joint against the transparent window. The X-ray film cassette 5 is removed from the sleeve 30 to expose the first 39 in the window for accurate placement of the patient's joint in the center spot. The tube 60 is then slid into place against the head 50 of the patient and the X-ray film cassette 5 is placed into the sleeve 30 to expose the third and fourth quarters of the film for the closed and opened view of the other temporomandibular joint of the patient.

The advantages of these provisions of the spot or target X-ray focusing device include a simplified apparatus that provides accurate duplicatable radiographs of the temporomandibular joint area and other parts of the human body. This apparatus provides a very simple technique with accurate focusing, and enables the dentist and physician to make repeated studies on the same anatomical part from the same direction of the same person under varying circumstances at various times. This invention will enable dentists and physicians to make X-ray studies of the mandibular joint areas as readily as they now study the teeth, and of bone fractures and joint displacements before, during and after various treatment procedures.

This apparatus provides a new phase of temporomandibular joint radiography which shows the relationship of the joint to the various parts of the ear from the vertex viewpoint. The joint consists of a condyle which is olive shaped with its long axis across the face. It is loosely located in relation to a concave-convex fossa or bone surface of the skull. The joint is surrounded behind, above and inwardly by the external auditory meatus, ear drums, middle ear and eustachian tube. The relationship of the condyle to the fossa and these parts of the ear is dependent upon the relationships of the lower jaw to the skull and of the lower teeth to the upper teeth. Since these relationships change throughout life, particularly with the eruption of the deciduous and permanent teeth, with the breakdown of the teeth, and with dental replacements of the teeth, it is obvious that a complete study of the joint should include vertex views which show the long axis of the joint and condyle.

I have found that the relationships of the condyle of the joint to the external auditory meatus, ear drum, middle ear and eustachian tube can be shown by these radiographs by use of my invention. This is done by using the opposite side or back 35 of the sleeve 30 which has a rectangular opening 36 in its center opposite the front transparent window and the fixed focus arrangement of the guide-bar 40 that maintains the cone 65 in the focus center at 90° in the vertical dimension or 0° in horizontal dimension in relation to the cassette and film. The patient or subject is placed with his head in a recumbent posture so that the vertex axis of the head is parallel to the cone 65 at 90° to the sleeve 30 which is placed against the top of the head of the patient. The tube 60 is then used to take a telegraphic view of the apparatus is turned clockwise around the patient's head on the right side until the operator sights the ear tragus in the lateral or outside center of the cone orifice. This usually requires a 20 to 30° shift from the vertex axis of the patient's head in the horizontal plane. The tube 60 is then moved into contact with the neck and lower jaw and locked in position. The X-ray machine cone 65 is then placed in the end 60b of the lead-lined tube 60 of the appliance and the radiograph taken of the joint.

ear area. The X-ray film cassette 5 is then moved through the sleeve to expose its other half and the operation is repeated on the left side where the rotation of the apparatus is counterclockwise.

This invention thus provides for multiple X-rays on single films. It simplifies the lateral radiographic studies of the temporomandibular joints by providing four views on one 8 x 10 inch X-ray film. It also makes possible and provides a simplified technique for a new type radiographic study of the relationships of the joint to the ear by modified vertex view of the joint area. However, it is to be understood that the present apparatus is suitable for radiographic studies of any other part of the body where a series of radiographs of the same part of the body from the same and various angles at the same and varied times in the same and in different positions is required. The practical application of this apparatus and invention will be a great aid in dentistry and medicine in the many phases of diagnosis and treatment. It will enhance the value of practically all radiography by fixing the focus of the X-rays, intensifying the resulting radiographs, reducing radiation of the patient, and providing duplicatable, multiple X-rays of the area to be studied and treated. Its portable provisions enable and simplify superior radiographic results with sitting, standing and lying patients. The spot-focus intensifying action enables maximum results with the use of minimum voltage and milliamperage as in portable and dental X-ray machines.

It is also apparent that my apparatus provides means for making duplicatable radiographic views of the same area of the same patient at varying times and under varying circumstances. The apparatus may be moved up to a chair or operating table or bed for making duplicatable fixed, spot-focused X-ray studies of mandibles, joints, etc., in order to show pathology and/or effects and progress of treatments as in setting broken bones, pinning bones and joints, and other dental, surgical and orthopedic procedures, for taking lateral and vertex view radiographs of the temporomandibular joints and the external auditory meatus.

My apparatus thus provides the following novel features. Fixed spot focusing of the central beam axis of the X-ray beam through a localized area at certain degree angulation in the vertical plane and always at right angle to the film in the horizontal plane. It provides duplicatable radiographs of the same area of the body at the same and subsequent periods of diagnosis and treatment. It reduces the quantity of X-ray exposure of localized area of the patient to be studied by focusing central X-ray beam through that area. It eliminates direct and secondary radiation exposure of other parts of the patient's body by limiting X-ray beam to area to be studied. It provides a simplified method of using angled guide-rods which guide the X-ray opaque walled tube to direct central axis of the X-ray beam to the localized area upon the center of area of unprotected film. It provides for multiple radiographs on single film by protecting ¾ and ⅓ or other portions of film from X-ray beam and exposing remaining ¼ or ⅓, etc., to the central X-ray beam emitted from the opaque-walled tube. It provides portability of the entire apparatus which provides all of these novel features for use at operating tables as in bone-setting, joint surgery, etc., of orthopedic surgery, chair-side as in dentistry and orthodontology for temporomandibular, mandoid and ear radiography, and bed-side in medical and surgical diagnosis.

I claim:

1. Portable apparatus for spot-focused radiography of the temporomandibular joint and parts of the body which comprises a portable vertically adjustable support, a cassette carriage opaque to X-rays connected to said support, said cassette carriage having open ends and parallel front and rear walls, said cassette carriage being rotatable on said support about an axis at 90° from the floor plane supporting the portable apparatus,
a guide-bar having means connecting same to said support above said cassette carriage connection, said guide-bar being positioned with its longitudinal axis at a fixed angle to the supporting axis of the said cassette carriage, a hanger arm slideable on said guide-bar, said hanger arm being connected to a hollow open-ended X-ray collimator tube having its longitudinal axis positioned parallel to the longitudinal axis of the guide-bar, the wall of said collimator tube being opaque to X-rays, one end of said collimator tube being adapted to receive a stream of X-rays and the other end being adapted to contact the body of a person, said cassette carriage being provided with optically transparent windows in the front and rear walls thereof, said windows being provided with locating marks and being visually observable in relation to a landmark on the body portion to be radiographed, whereby X-rays emitted from the collimator tube will be focused on the locating marks of said transparent windows.

2. A portable apparatus for spot-focused radiographs as defined in claim 1, wherein the longitudinal axis of the guide-bar is positioned at right angles to the supporting axis of the sleeve.

3. A portable apparatus for spot-focused radiography as defined in claim 1, wherein the longitudinal axis of the guide-bar is selectively positioned at a predetermined angle above and below the horizontal.

4. A portable apparatus for spot-focused radiography as defined in claim 1, wherein the open ends of the tube are provided with yieldable cushioning material.

5. A portable apparatus for spot-focused radiography as defined in claim 1, wherein the rear-wall window has a length from top to bottom of slightly less length than the vertical length of the sleeve whereby two radiographs may be made on a single X-ray film upon exposing said rear-wall window to a stream of X-rays.

6. Portable apparatus for spot-focused radiography of the temporomandibular and other joints and parts of the body which comprises a portable support, a rectangular sleeve opaque to X-rays carried on said support, said sleeve having open ends and parallel front and rear walls, said sleeve being rotatable on said support and positioned on an axis at 90° from the floor plane supporting the portable apparatus, the upper portion of said sleeve being provided with an upwardly extending post, a guide-bar having a hub at one end, said hub being removably retained on said post, said guide-bar being positioned with its longitudinal axis at a predetermined angle to the supporting axis of the said sleeve, a hanger arm slideable on said guide-bar, said hanger arm being integrally connected to a hollow open-ended tube, the wall of said tube being opaque to X-rays, one end of said tube being adapted to receive a stream of X-rays and the other end being adapted to contact the body of a person, the said front wall of said sleeve being provided with a transparent rectangular front-wall window having intersecting center lines marked therein as a target area, said window having the dimensions of one-quarter of an X-ray film cassette adapted to be removably positioned within said sleeve, said front-wall window being located in the medial lower portion of said front wall, said sleeve having overall dimensions slightly greater than one and one-half the width and length of said cassette whereby said cassette may be positioned in relation to the said front-wall transparent window to expose one quarter of the X-ray film retained in the cassette while the remainder of the X-ray film is unexposed to X-rays, the rear wall of said sleeve being provided with a rectangular transparent rear-wall window in alignment with the front-wall window of said sleeve and of substantially the same width as the said front-wall window, said rear-wall window permitting visual observation of centering lines in the front-wall window in relation to the landmark on the part of the body to be radiographed.

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