„TECHNIQUE FOR ROENTGEN-PHOTOGRAPHIC REGISTRATION OF THE DIFFERENT CONDYLE POSITIONS IN THE TEMPORO-MANDIBULAR JOINT" *)

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In the course of the studies I have been carrying on ever since 1921 concerning balanced articulation and its great significance for the physiological function of the mandibular and dental organs my attention was early drawn to the retruded position in the "fossa glenoidalis" which the condyle occasionally takes in lowered bite forms, and likewise to certain disturbances which are described by the patient as "rushing" in the ears, snapping and creaking in the joints, and a greater or less reduction of hearing, which often occur at the same time in these patients. In a previous lecture on "balanced occlusion" before the Scandinavian dental Congress at Stockholm in 1926, I think I demonstrated theoretically as well as practically that by opening (raising) the bite, thus effecting an advancement of the condyle-head in the "fossa", one can really, in some cases, find a remedy for these troubles. Hitherto we have always had to work, as it were, on the basis of our "feeling" or experience, since no fixed method has existed for exactly determining the condyle position either in too low bite or in a corrected one.

This defect in the diagnostical methods becomes still more

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obvious when we penetrate further into the laws of balanced articulation, for one must constantly deal with and take into account conceptions like "the *physiological* and *physical rest positions*" for the lower jaw introduced by P l a n e r or the conceptions introduced by myself of "*the real and habitual central occlusion position*". It is evident that in both these cases the condyle will occupy different positions in the fossa. An examination of these problems would lead us too far and, moreover, is strictly speaking beyond the scope of the problem I am now going to deal with. I must therefore presuppose that they are already known or refer the reader 1. to K a r l T h o r l e i f's meritorious work "On the lowered bite and its prosthetic treatment" and 2. to my own work "On balanced articulation and its significance for the treatment of marginal paradentitis", published in Sv. Tandl. Tidskr. 1932 and Dental Cosmos, 1933. It is therefore a somewhat pressing desideratum to obtain a method of registration and diagnosis for the determination of these condyle positions.

The modern prosthetic operator is daily concerned with another conception viz. "the inclination of the condyle path"; indeed, he measures it indirectly by his "taking of the bite" in protrusion and his subsequent adjustment of the individually adaptable articulator though, obviously, direct measurement as a check on the patient cannot be employed.

In all the cases now referred to a radiogram of the temporo-mandibular joint ought to afford a good deal of information as to whether this could be exactly and practically performed.

Briefly this has been the trend of thought which led me to seek a Roentgen-photographic method which should give, simply and exactly, a picture of the position of the condyle in the fossa. Theoretically this has been demonstrated by a number of authors, and the conditions may be briefly described as follows Fig. 1: "In normal articulation between intact dentures the condyle does not rest at the bottom of "fossa mandibularis". Contact occurs here between the anterior part of the upper side of the condyle and the lower third of the posterior surface of "eminentia articularis". Between these osseous surfaces lies the thin middle part of "discus articularis", while the thick posterior part of the latter fills the

interval between the condyle on the one side and the bottom of the fossa and the posterior wall on the other, here serving as a resilient shock-absorber. When the lower jaw is opened, there is a protraction of "musculus pterygoid. externus" which is attached to the anterior surface of the condyle, immediately below the afore-mentioned articulation surface. Fibres from this muscle, which Prentis calls "musculus sphenomeniscus", are attached to the anterior edge of discus which thus, at the same time, undergoes forward protraction. Consequently when the mouth is opened the condyle normally assumes the position shown in Fig. 2, where the posterior part of the upper side of the condyle lies in front of and below the top of "eminentia articularis". Moreover, we appear to be justified in assuming that the normal articulatory conditions now described are dependent on normal articulation between the teeth, so that a lowering of the bite will imply a slackening of "ligamentum temporomandibularis" and lowered tonus in "musculus masseter, temporalis and pterygoid. externus", thus bringing the condyle nearer to "os temporalis" — in other words causing retrogression of the condyle in the "fossa".

There are numerous works dealing with the various changes and disturbances in the temporomandibular joint and its function. I wish to recommend to those interested the extremely meritorious works of G o o d f r i e n d. (Vide bibliography). His works are of special interest to us dentists, because he convincingly shows that certain forms of Subarthrosis and Dysarthrosis are directly connected with articulation and height of bite. Fig. 3 is taken from G o o d f r i e n d's work and shows the shape and position of the condyle in the fossa in these two anomalies as compared with normal conditions.

This very brief anatomical account was necessary for the proper understanding of the argument in what follows.

When it is a question of roentgenographing the temporomandibular joint, we must assume a priori that great difficulties will have to be overcome. Owing to the topographical-anatomical conditions, it is hard to obtain a clear and exact picture of the condyle free from shadowing, and it is also a

problem, with the limited apparatus at a dentist's command, to obtain good and contrasty pictures without over-exposure. From the outset I have regarded it as indispensable that every dentist should be able to take such control pictures with his own dental Roentgen-apparatus. Consequently, we must exclude all methods requiring hospital apparatus. So I had little hope of finding in the medical Roentgen literature any method of adjustment adapted to my purpose, and this proved to be the case. Moreover, an elaborate apparatus almost always presupposes that the patient be placed in a frontal, dorsal or lateral position, this being highly objectionable when, for instance, one has to register a relaxed central occlusion position — that is, a position where the occlusal surfaces of the teeth are no longer in contact, but the lower jaw hangs freely, so to speak, in the relaxed muscles.

The determination of this position is extremely important in the reconstruction of a balanced articulation, but it cannot be determined when the patient is in any other than the upright sitting position, with the head inclined somewhat forward. From S c h w a r t z' work "Kopfhalt und Kiefer" we know that the position of the head influences that of the mandible and thus, obviously, that of the condyle, so that when the head is inclined forward, the mandible sinks more ventrally and vice versa. When the head is leaned to one side towards the cassette, as in most of the methods described in dental literature, there must obviously be an immediate displacement of the condyle in the fossa when the teeth are not kept tightly closed. The median plane through the head must obviously remain vertical all the time. As to the best position for the patient while being roentgenographed, I am in full agreement with H i l d e b r a n d, who says in his doctor's thesis, "Studies in the masticatory movements", that the head should be placed so that the "Camper plane" — that is a plane stretching through "porion acusticus" and "nasospinale", or in common parlance from the nostril to the outer ear passage — should coincide with the horisontal plane. This arrangement of the patient's head is also recommended by R i c h a r d G r o h s. In the method I have

elaborated and described in this paper, this position of the head is assumed.

A scrutiny of the methods referred to in dental literature for the roentgenography of the temporomandibular joint reveals the fact that they do not fulfil the requirements which I have outlined in the foregoing.

In the method described by Hildebrand in the aforementioned thesis for the carrying out of "Positional Photography" the patient is given a procumbent position with a lateral position of the head. From the foregoing it is obvious that this position cannot be employed for the registrations desired by me. I have tested the Porde-adjustment employed by Hildebrand with patients in a vertical position, but it did not give the sharp and exact profile of the condyle-head which I was seeking. (I shall return to this later on when dealing with the deduction of the rays direction in my technique).

In Goodfriend's meritorious work: "Anomalies of the mandibular articulation", the author does not fully describe the adjustment employed. From his reproductions, however, it would appear that he employed the direct profile position. The contours of the desired parts had to be drawn in afterwards, as the contrasts were rather poor owing to the dense bone areas which the rays had to penetrate. The roentgen apparatus employed seems not to have been a dental one, for the plates have a hospital stamp. My first experiments date back to the New Year of 1933. The method I am advancing to-day was theoretically complete in August, 1934, as testified by documents handed over to the Swedish Society of Dentists on 15th August, 1934. The apparatus has, however, been remodelled and improved twice during the past year. In the August number of the "Journal of the American Dental Association 1935" Dr Robert Gillies, in an article entitled "Roentgen-ray-study of the Temporo Mandibular Articulation", describes a method which at first sight may seem very like the one worked out by myself. A closer study, however, will reveal that the two methods are essentially different in two important particulars. Firstly, the patient's head is inclined obliquely sideways towards

the cassette. I refer to foregoing argumentation and, secondly, the incidence of the central ray is wrong. (Compare my demonstration of the correctness of the opposite direction in what follows). Since the priority of my technique may be hazarded by further postponement of its publication, I have decided to make it known although it only forms one step — the first — resulting on the investigations which I have long been carrying on, and to which I have referred in my introduction.

For the study of the different condyle positions in the fossa it is desirable that the condyle should be projected on to the plate (film) in pure profile, free from overshadowings. The first requisite is that the direction of the central ray should coincide with the longitudinal axle of the condyle — that is „obliquely from above — from behind — forward — downward". Gillies' beam path is the very opposite: "obliquely from above — from in front — backward — downward, with the same angle to the horizontal plane as my studies had proved most suitable. As well known, the two condyles are slanted in such wise that the prolongations of their longitudinal axes intersect each other at an angle of about 150 degrees. Moreover the incidence of this beam must be such as to make it pass the fewest and least dense bone areas possible, so as to obtain a maximum of sharpness without too long exposure. (The relatively small capacity of the dental roentgen apparatus must be borne in mind).

The central ray should therefore pass through the cranium above "sella turcica" and "pars petrosus" of "os temporalis", since hereby only the two thin bone walls of os temporalis or parietale on the infall side and the roof of fossa glenoidalis on the outfall side will be traversed. I refer to Fig. 4.

The following geometrical deduction of the angle of incidence of the central ray and the placing of the plate (cassette) can then be made:

1) the cranium is placed so that the sagittal plane through the cranium will coincide with the perpendicular line, and so that the camper plane will coincide with the horizontal plane. (See Figs 5 and 6).

2) A line AC parallel to this perpendicular line is drawn through the condyle. (See Figs. 5 and 7).
3) An arbitrary horizontal plane is laid through the cranium at Point A — here represented by Line AB — the angle BAH will thus be 90° (See Fig. 5).
4) Line DC represents the inclination of the plate (cassette) to the perpendicular line, and this angle A CD is 15 degrees. This angle has been empirically determined as follows: the central ray DE, which ought to be at right angles to the plate D C for obtaining the correct projection, was varied until it (the line XY parallel to the line AE) cleared "sella turcica" and "pars petrosus". (See Fig. 4).
5) It was then found that the line DE fell from above on to the horizontal plane AB, making the angle EAB, which is, 15 degrees. Further, it fell obliquely from behind, making an angle with the frontal plane through A. (represented by the line AB) that is the angle FAB, about 15 degrees. (See Fig. 8).
6) Line ED thus represents the angle of incidence of the central ray, passing through point A and meeting the plate at right angles at D, to the horizontal as well as to the frontal plane. (See Fig. 8).
7) In orde to make this central ray pass through the condyle (Point Y, Fig. 4) a line XY is drawn parallel to DE through Y and this will pass through the cranium at point J. Fig. 6. This is the point towards which the central ray must be directed. How is this point determined?
8) Through the outer auricular orifice K a horizontal line KL is drawn, and through point J a line JM is dropped at right angles to KL. These two lines intersect each other at point N. The distance NK is 20 mm; that is exactly the same measurement as found in Doctor R i e c h y's "Condyl Marker", so that I made use of it in constructing my "*Beam direction indicator*" which, with sufficiently exact approximation, indicates how the beam, that is the conical point of the roentgen tube, should be directed towards the head. The distance JN is 60 mm.

I now proceed to give a more detailed account of the outfit and the technique of adjustment for the taking of these roentgenograms.

The roentgen apparatus employed is a Ritter of the type hitherto most in use and the angles of adjustment, as well as the measurements and times of exposure indicated in the following, consequently refer to this type of apparatus.

The beam direction-indicator consists, as appears from Figs. 9 and 10, of two parts 1 (Dr. R i e c h y's "Condyl-Marker", and 2) the beam-direction-finder constructed by myself, and the way of using it appears immediately from Fig. 11.

It is constructed in such wise that the measurements determined according to point 8 of the deduction are automatically transferred to the patient's head with the outer auricular orifice as the starting point.

The chair on which the patient sits during the exposure is provided with an ordinary neck-rest which, however, is altered so that the horizontal arms on which the neck-rest cushions run have been considerably lengthened in order to serve as an attachment for the *cassette-holder*. This is plainly shown in Fig. 12*a*.

This figure also shows the respective positions of the roentgen apparatus and the chair.

The long carrier arm (12 b) is swung out at right angles to its underpart (12 c), so that the plumb line (12 d), the vertical raisable arm (12 e), and the guide-rod (12 f) lie in the same plane. The chair is always placed at a distance from the roentgen apparatus which has been determined once for all, and in such wise that the middle angle of the neck-rest coincides with the plumb line. To obtain the desired distance between the cathode and the plate (casette) the joint is fixed (12 g) at 45 degrees, when this distance is about 45 centimeters.

The *cassette-holder*, whose construction appears from Fig. 13, fixes the cassette at a constant angle calculated so that the central ray always remains at right angles to the cassette and can be raised, lowered and moved sideways, forward and backward by easily controllable movements.

Fig. 13*a* shows the finaf construction of this cassette-holder.

The patient is now placed in the chair, so that the sagittal plane of the head coincides with the plumb line, and C a m p e r's plane with the horizontal plane. See Fig. 14.

The neck-rest cushions are adjusted so that there is good support under the back of the head, and the head is fixed by means of a band around the forehead. The back should rest against the back-support. See Fig. 14.

The cassette-holder is adjusted to the cheek until there is contact at some point.

By means of the beam-direction-indicator the incidence of the central ray is determined with the Meatus of the opposite side as the starting point. This can be read off once for all and determined on the scales which are attached to the stand of the roentgen apparatus. The adjustment, ready for exposure, is shown in Figs. 15 and 16. and the number of degrees readable on the scales (16 a) and (16 b) are respectively + 15° and 235°.

This adjustment is appropriate, as appears from the picture, for the photographing of the left mandible. For the right mandible the arm is swung to the opposite quarter, when 25 degrees will be read on scale b. Fig. 16.

From this picture it plainly appears that the tube, which has here been adjusted entirely according to the scales, really does with its point follow exactly the line (16 c) which here passes through the cranium in the direction deduced. (See the geometrical demonstration). The film I used for these photographs is Kodak, Diagnox, Double-coated Safety, X-ray films, Special, 9 by 12 cm.

The cassette is provided with double reinforcing screens. Time of exposure is 4 seconds. In order to enhance the contrast effects of the bone areas desired, by excluding secondary radiation, a "*Lysholm filter*" has been employed which certainly increases the time of exposure to 6 seconds but on the other hand it gives extremely fine and distinct outlines on the plate. The apparatus needs a current of 10 MAmp and 45 KV.

The method of adjustment which I have described has been worked out, as already mentioned, mainly as a method of diagnosis for the determination, on a given occasion, of the

condyle position in both temporo-mandibular joints. The patient remains all the time in the same position, and sufficient exactness is obtained, even without a too complicated outfit.

The method does not claim to satisfy all the requirements of a periodical-identical adjustment, although the results obtained from control-plates on various occasions seem to show that in this respect also a high degree of exactness can be obtained. This is shown with great clearness by the following series of six plates of one and the same mandible taken on different occasions. (See Fig. 23). The beam direction resulting form my experiments will be found, I believe, to yield a better and more exact representation of articular conditions in the tempore-mandibular joint than the methods previously employed.

Before I published these researches, two other authors had published investigations into the changes in the temporo-mandibular joint which closely border on my own. I desire therefore to conclude the present paper by saying a few words about them. Both of them are orthodontists, and they aim at showing by roentgen control of the mandible that changes in the joint can really be accomplished by orthodontic operations. In this connection I am obviously only interested in the roentgenographic technique which has been employed. One of them, a Swede named Sten Waldenström, has published a work entitled: "Changes in the jaw and mandibular joint when intermaxillary power is employed". He himself describes the method used for the taking of the roentgen controls which are referred to in his thesis in the following words: "The patient is placed in a procumbent position with his head turned to one side and with the mandible to be photographed against the top of the glass table". The roentgenograms were taken in a hospital. From my previous argumentation it will be seen that this method is also marred by the imperfections which I have endeavoured to avoid in the technique which I have worked out. To begin with, the patient must be sent to a hospital and then has to keep a position while being photographed which only when the teeth are tightly closed (that is, with the jaws in a phy-

sical rest-position) permits of a proper representation of the position of the condyle in the fossa without displacement. For the controls desired by W. this position may perhaps be satisfactory, but for the registrations I wanted to make with the lower jaw in a relaxed rest-position, it is not exact enough. The other author, Sidney Riesner, "Temporomandibular Articulation", falls into the same error in his way of taking roentgenograms of the mandible, namely in letting the patient lean sideways. See Fig. 41. A close scrutiny of his otherwise excellent illustrations will show that his outfit is too complicated in spite of the evident employment of a dental roentgen machine, for these controls to be possible for the average dentist and that the same inexactitude must arise in all methods of adjustment known to me, whenever the jaws are not kept tightly closed in physical occlusion.

The following illustrations will show the result of the X-ray-technique in some actual cases, representing different conditions in the temporo-mandibular joint, as will be described from case to case.

For the right understanding of the pictures, the following explanations are necessary: In the upper row the registrations of the left condyle, in the lower row those of the right are reproduced, and the degree of opening of the jaw increases from left to right, so that the most closed position is shown first — (reading from left to right) and followed by the more protruded ones.

Fig. 17. Presents conditions in the Temp.-mandibular joint that might be described as normal and very typical of normal occlusion. The condyle is correctly positioned in the well developed fossa glenoidales and moves forward up on to the top of eminentia articularis just as described for fig. 1 and 2 above.

Fig. 18. Represents a "closed-bite" case and is very typical of such a case. The vertical row to the left represents the "physical occlusion" — that when the patient bites tightly, thereby forcing the lower jaw to its most retruded position. In the middle row is shown the "physiological

occlusion" — that is the unstrained centric occlusion; it will be noticed that in agreement with the theoretical description, the condyle has moved somewhat forward, thereby assuming a more normal position in the fossa. — Finally the row to the right represents the protrusive conditions.

Fig. 19. is from a patient suffering from Dysarthrosis of the right joint. As soon as she opens her jaws more than 1 ½ cm., the right condyle jumps over eminentia articularis with a clicking sound, while the left one stays in normal position. The displacement of the right condyle can be seen and felt in front of and to the side of eminentia.

Fig. 20. Comes from a similar case of Dysarthrosis of the left joint; a clicking noise, audiable across the room, was produced as soon as the jaws were separated. In this case the condyle was displaced chiefly laterally, creating a marked prominence on the left cheek.

Fig. 21. Illustrates the value of this X-ray technique as a check on the correctness of central occlusion and the successful establishment of the proper degree of opening of the bite in an edentulous case, where, owing to the loss of contour and extreme absorbtion of the jaws, it was very difficult to find the proper height of the bite. With the bite-rims tentatively built up to restore the esthetic effect — checked by profile X-rays before and after restoration — these joint-controls were made to show whether the condyles had come into their right positions in the respective fossae glenoidalis in central occlusion.

Fig. 22. Was taken as a check on the proper bite-opening in a case of aquired prognathism due to a closing of the bite, which in turn was caused by the loss of some molar teeth.

In opening the bite and building the restorations in this new position, I created an "end to end" bite, and the X-ray checks on the joints proved that the degree of opening was the proper one.

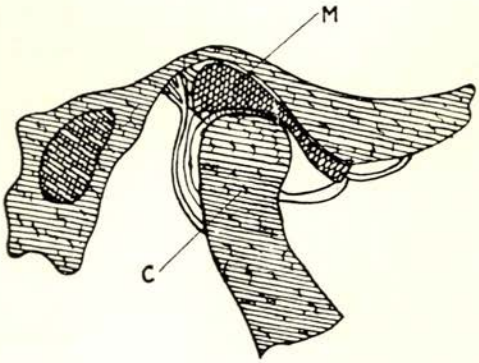


Fig. 1.

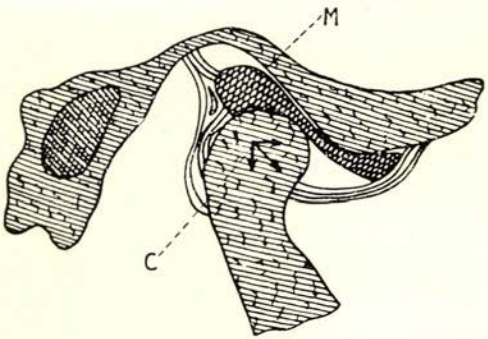


Fig. 2.

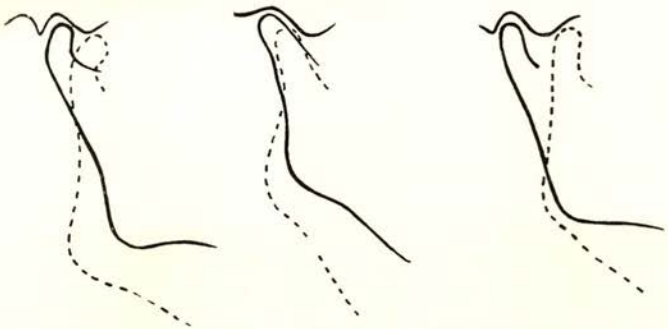


Fig. 3.

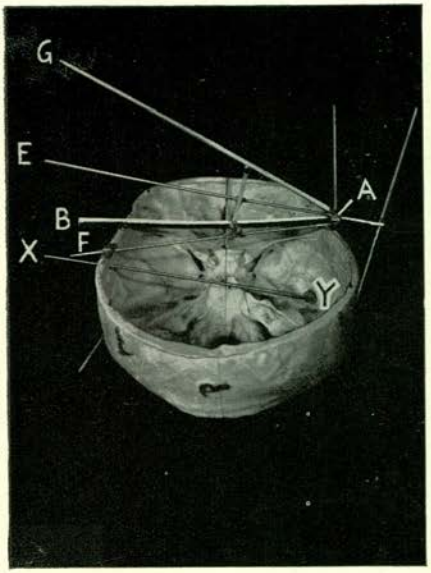


Fig. 4.

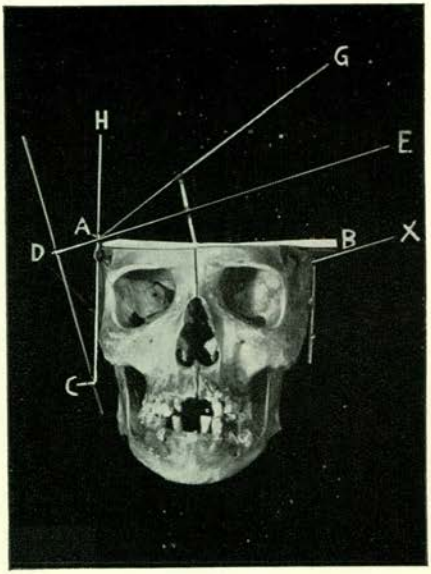


Fig. 5.

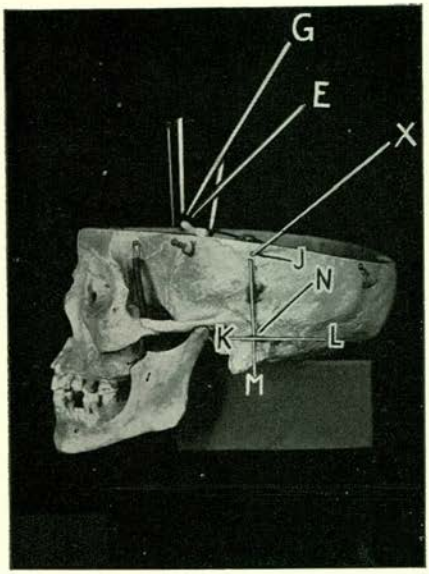
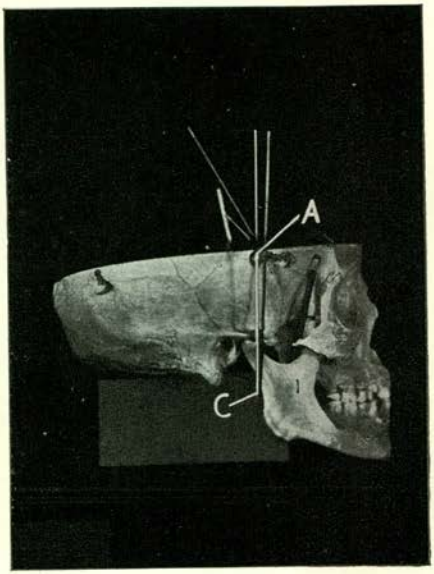


Fig. 6.



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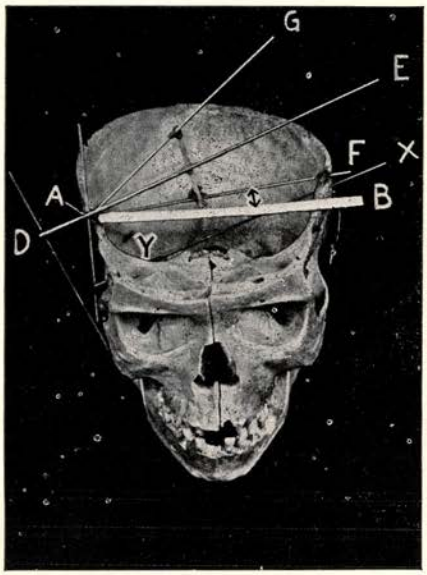


Fig. 8.

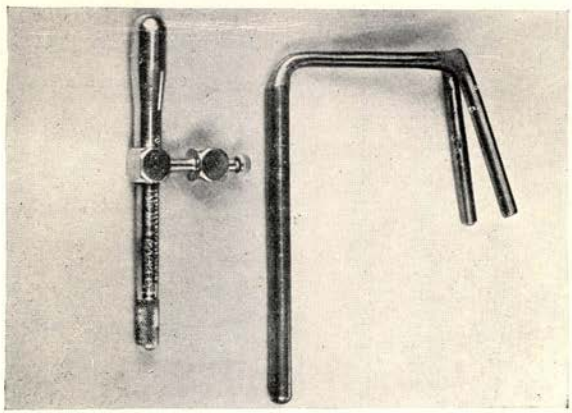


Fig. 9.

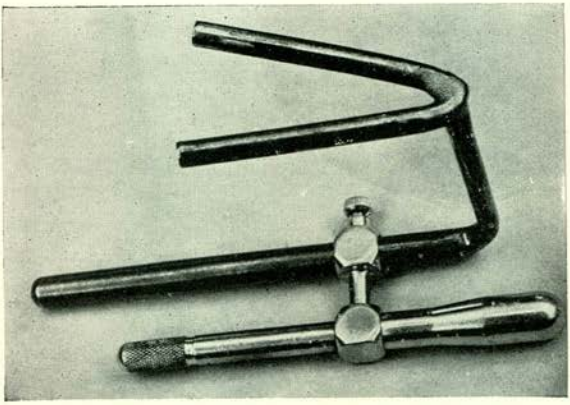


Fig. 10.

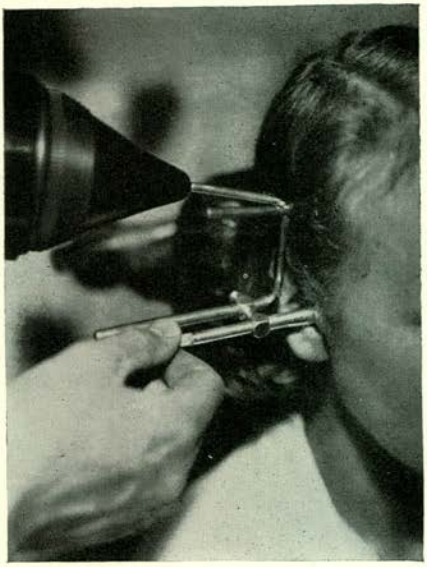


Fig. 11.

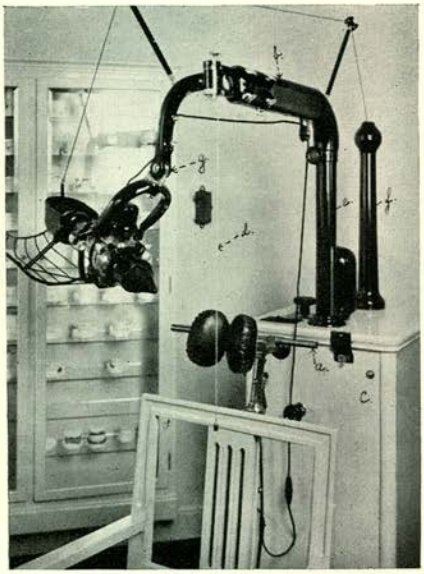


Fig. 12.

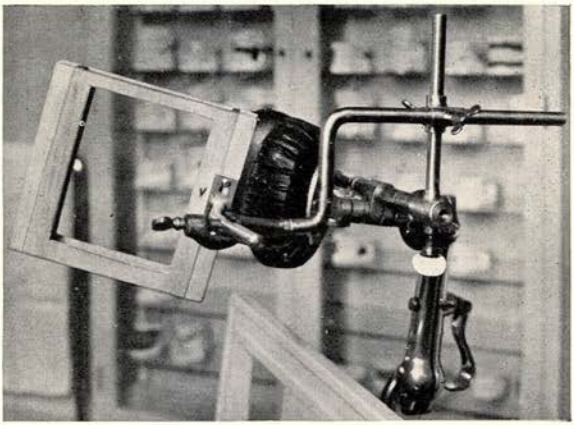


Fig. 13.

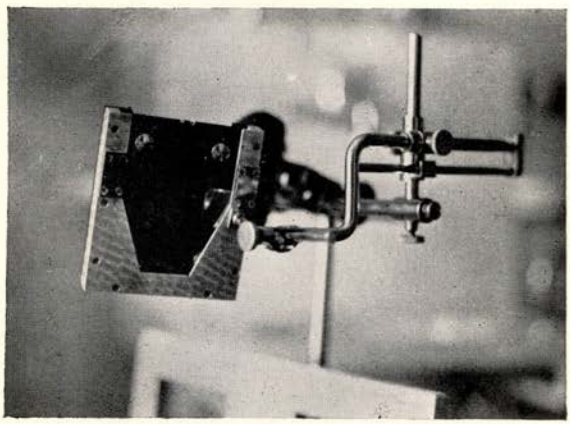
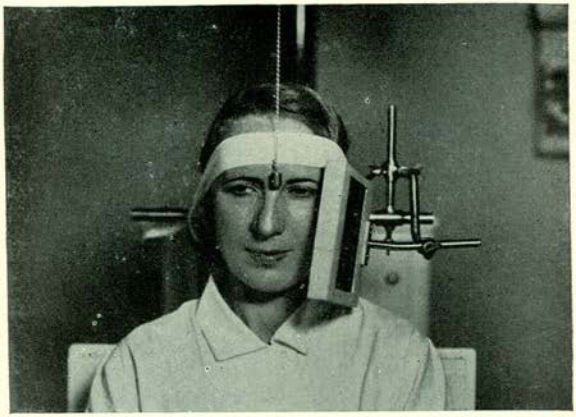


Fig. 13a.



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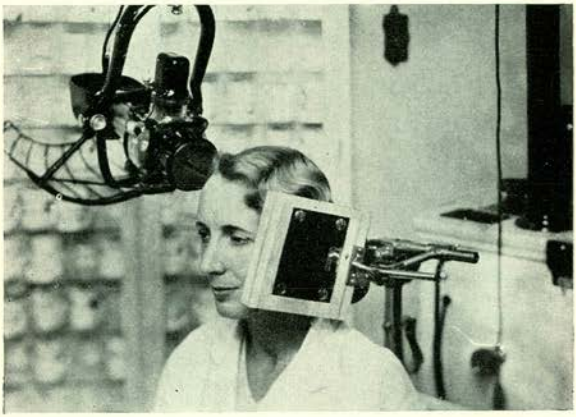

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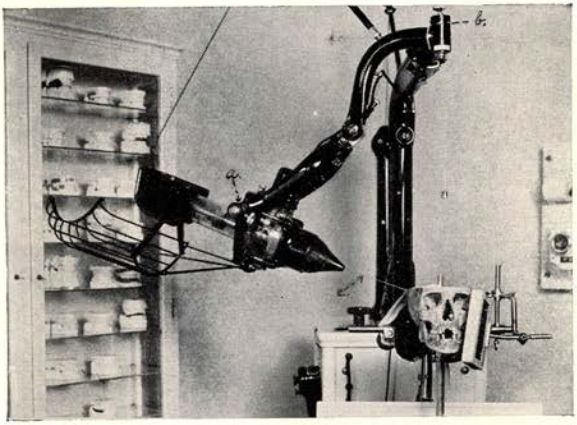

Fig. 16.

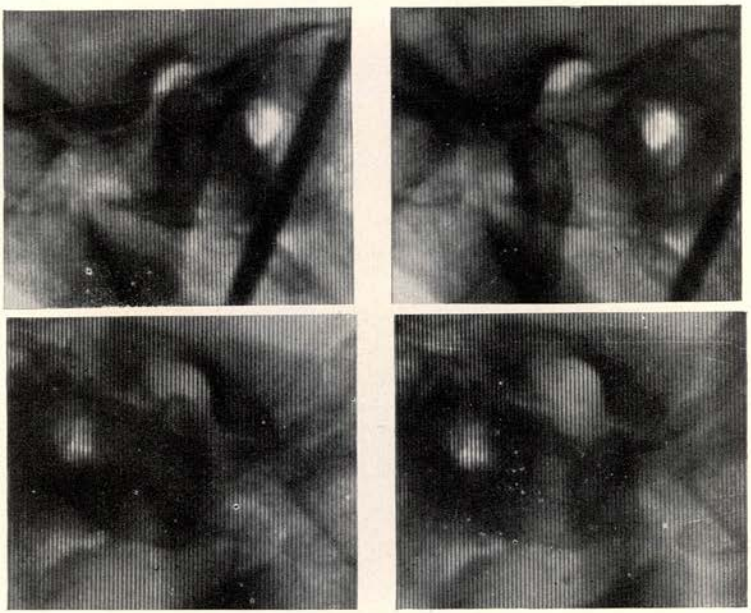

Fig. 17.

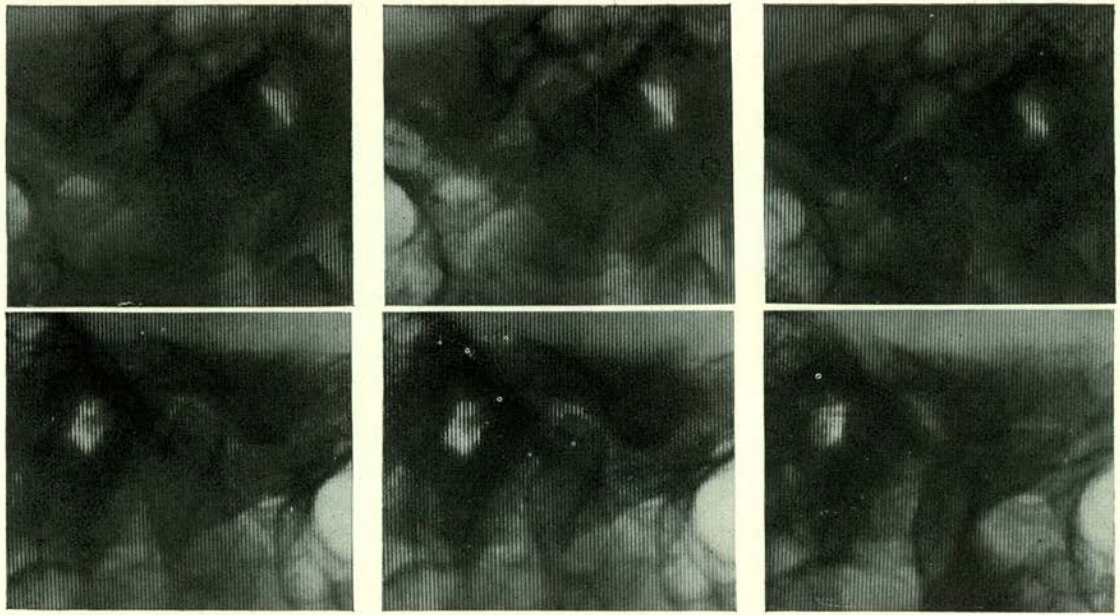

Fig. 18.

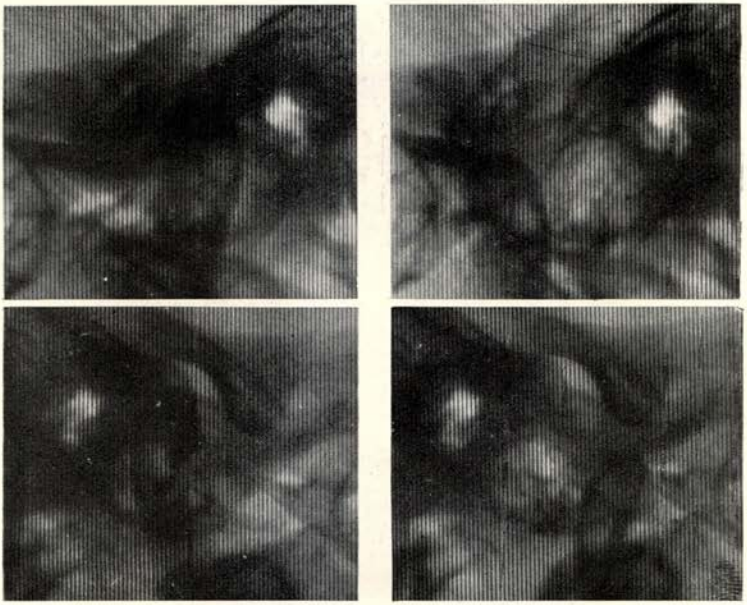

Fig. 19.

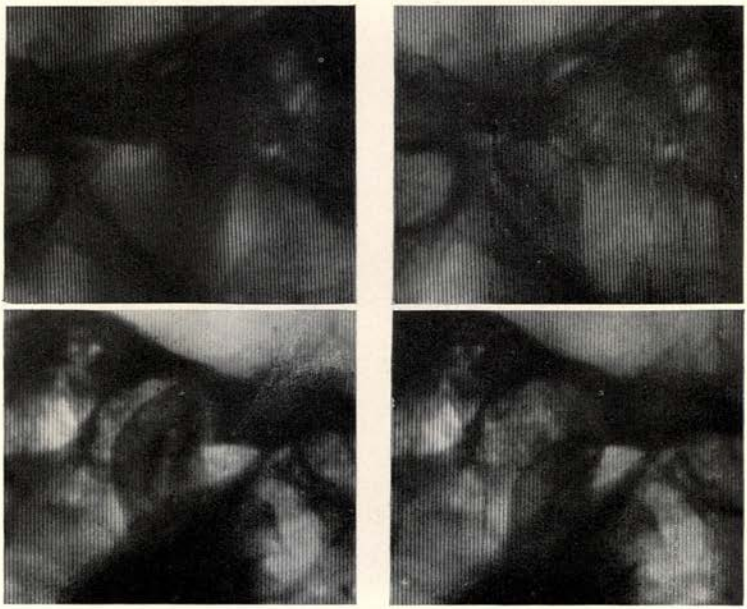

Fig. 20.

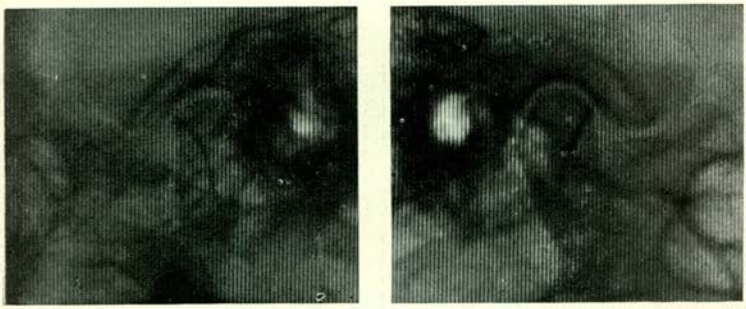

Fig. 21.

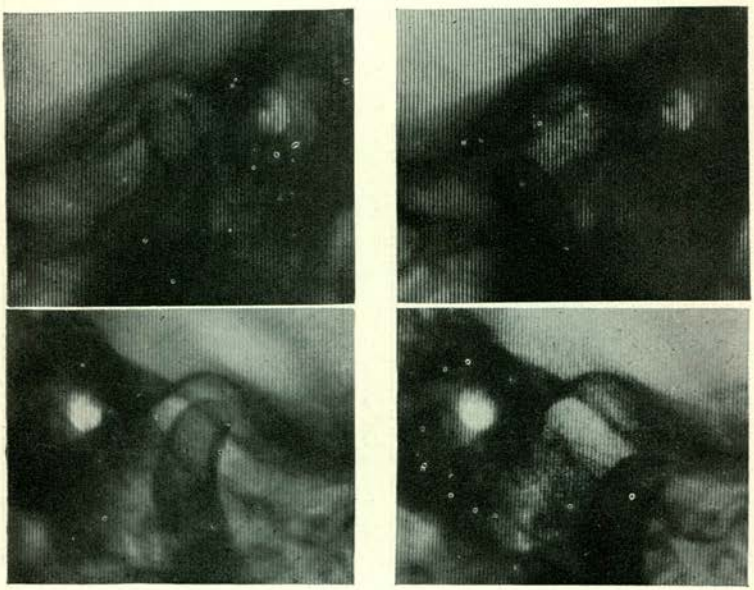

Fig. 22.

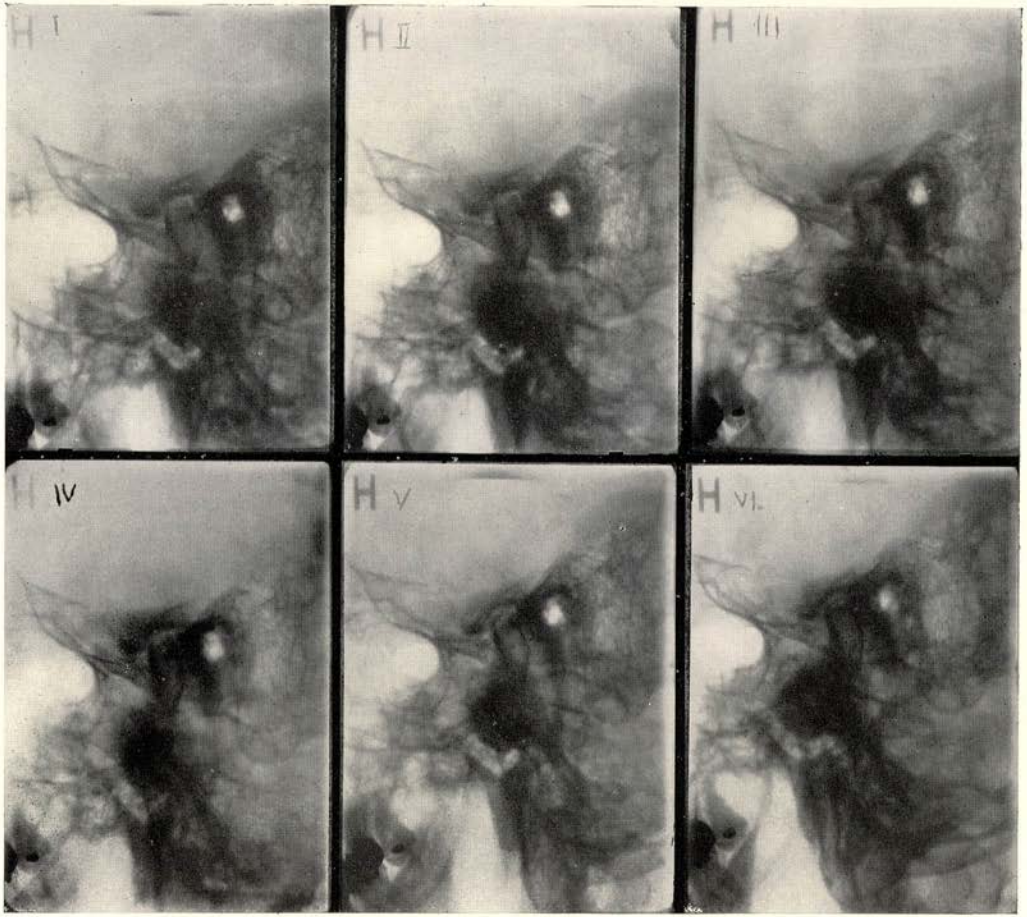

Fig. 23.

Fig. 23. Is a series of six X-ray exposures on the same joint, taken on different occasions to show the uniformity of the reproduction of the anatomical conditions in the temporo-mandibular joint.

The dental nurse took the exposures quite unassisted, only observing the author's adjustment technique as outlined above to show how automatic and at the same time how exact the technique is.

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