A NEW "TRIANGLE TRANSFER" METHOD FOR STUDYING MANDIBULAR MOVEMENTS ON THE BASIS OF CEPHALOMETRIC ROENTGENOGRAMS

PRELIMINARY REPORT

by

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Studies of the movements of the mandible have been of far-reaching importance in dental science as a whole. To mention only one example: the study of the opening and closing movement and of protrusion and lateral movements has strongly stimulated the development of the present theories of articulation and the designing of articulators. Special attention has been paid in dental literature to the physiological rest position of the mandible, the freeway-space and the path of closure from rest to occlusion position. The rest position is very important especially as a diagnostic starting-point and it is a decisive factor in drawing up treatment plans (e.g. the determination of the bite height of dentures). Scientific study of the freeway-space, and of the movements of the mandible in general, become possible after Broadbent and Hofrath, at the same time but independently of each other, devised the roentgenologic-cephalometric method (1931). This method of skull roentgenography has served chiefly the purposes of orthodontia, and on its basis several systems have evolved for the study of mandibular growth and development and for the classification and diagnosis of anomalies. The question of the relation of the condyles to the movement of the mandible from rest to occlusion position has been under discussion for a long time, and pertinent studies have given highly contrasting results. Thus, for example Thompson, Mc Collum and Ricketts consider that the movement from rest to occlusion

in "normal" cases is a pure rotational movement the centre of which is the axis between the centres of the condyles (the so-called intercondylar axis), and that there does not occur any gliding movement of the condyles. On the contrary, for example Prentiss, Lord, Hildebrand and Higley & Logan consider this a combined rotatory and gliding movement. Compared with the study of the opening movement, the interest aroused by protrusion and lateral movements has been considerably less. I

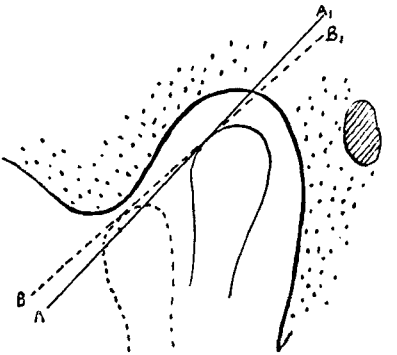

Fig. 1. Rough schematic drawing of so-called shadow displacement error. Path of condyle, AA, its true direction, BB, erroneous change in direction due to shadow displacement.

have found no single report of studies, by the roentgenologic-cephalometric method, of the so-called anatomical path of the condyle in connection with protrusion and lateral movements.

The methods hitherto used in the analysis of mandibular movements as seen in skull roentgenograms are almost without exception based on the so-called tracing method. In evaluating this method attention must be paid to three points:

1. The so-called cumulative sources of error. The boundary between bone and soft tissue is somewhat diffuse also in a good cephalometric roentgenogram, and the tracing paper increases the inaccuracy. To place a traced drawing accurately over another roentgenogram taken of the same skull is difficult and involves considerable possibility of error. The tracing of the outline of the mandible depends to a great extent upon the accuracy of the drawer's eye and hand. If the movement is only slight, the

definite limits of the new position of the mandible cannot possibly be seen under the tracing paper.

2. The region of the condyle often appears unclearly in a cephalomtric roentgenogram owing to additional shadows in the soft tissues and the skull.

3. The roentgen profile of the mandible, as well as of all objects containing surved surfaces and having depth in the direction of the exposure, changes its shape in the new position. This is termed the shadow displacement error (Fig. 1).

Because of these three sources of error the so-called tracing method cannot be considered entirely reliable. A proof of this is the variability of the results that have been obtained so far.

To the author's knowledge, only Thörne has made measurements direct from roentgenograms in studies of the rest position. However, his methods and results require checking. This will be reverted to later.

The author's method, so-called "triangle transfer", differs in two respects from the roentgenologic-cephalometric methods hitherto used.

1. For accurate measurement of the mandibular displacement, a small lead pellet (diameter 1.2 mm) is attached with wax to two teeth (incisor and molar) in the test subject's lower dental arch for the time of the exposure. The roentgen profile of the perfectly round pellets remains unchanged in spite of slight displacement of the lower jaw.

2. The mandibular displacement is shown by making two successive exposures on the same film (Figs. 2 and 3).

The round shadows of the lead pellets seen in the film are pierced exactly at their centre with a sharp-pointed pin; a magnifying glass is used for increased accuracy. With the aid of the displacement of these small dots on the film surface it is possible to determine the corresponding displacement of any arbitrarily selected point in the mandible, using simple triangle transfer. Three-legged divider, known by the name "tripod" (Fig. 4), has been devised specially for this purpose.

As two successive exposures are made on the same film, the head of the test subject must remain immobile during the in-

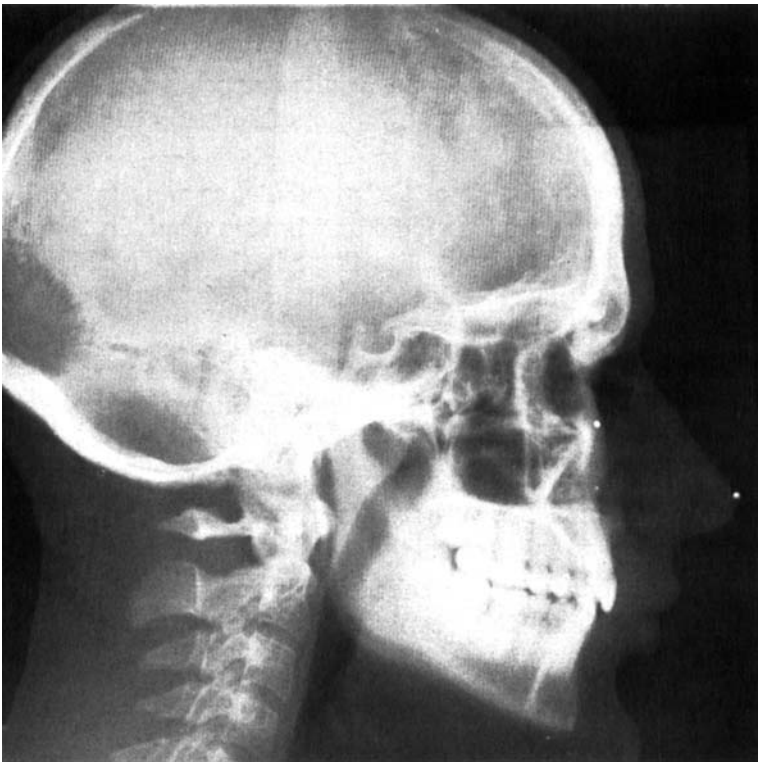

Fig. 2. Film obtained by two successive exposures. Skull unchanged in position, mandibular displacement clearly shown by the displacement of the lead pellets. Physiological resting position, occlusion.

terval, inspite of the movement of the mandible. This has been achieved by applying a tight bandage round the person's head over the supports incorporated in the cephalostat. Control pellets are attached to the skin, for example to the tip of the nose, and the immobility of their shadows is a sign that the head has not moved between the exposures.

In the author's opinion the new method reported above has the following advantages:

1. As the exposures are made on one and the same film, the cumulative sources of error associated with the tracing method are not present. The accuracy of measurement is also greater than when two films are used.

Fig. 3. Occlusion and protrusion.

2. The actual displacement of any desired point in the mandible can be determined, and there is no so-called shadow displacement error.

3. Exchange of casettes is not needed. Thus the possibility of a change in the position of the head between exposures is slight.

Exposures can be made not only in lateral projection but also in frontal and basal projection, and the lateral displacement of the lower jaw, and of the condyle in particular (so-called Bennet movement) can then be studied and measured.

This method is being used in the author's studies at present in progress; they are concerned with the physiological rest position of the mandible, the site of the centre of movement of the

mandible from rest position to occlusion, and the paths of the condyles in connection with closing, protrusion and lateral movements.

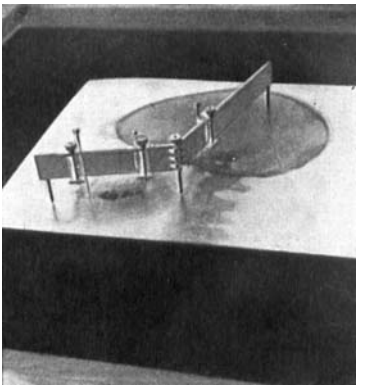

Fig. 4. The three-legged dividers or "tripod" devised for triangle transfer method seen in position on a cephalometric film.

I wish to thank the Director of the Institute of Dentistry, Prof. Eero Tammisalo, who kindly gave me access to the x-ray and other equipment of the Institute, including the use of films and other material. My thanks are also due to Dr. Kalevi Koski for much valuable advice in the field of cephalometric roentgenography, and to Dr. Yrjö Paatero for great help and support in evaluating roentgenological problems in general. Hammasväline O/Y supplied the "tripod" and made all required improvements in its construction, for which I wish to express my appreciation.

ZUSAMMENFASSUNG

NEUES "DREIECKVERSCHIEBUNGS" VERFAHREN ZUR UNTERSUCHUNG DER BEWEGUNGEN DES UNTERKIEFERS AUF BASIS VON KEPHALOMETRISCHEN RÖNTGENPHOTOGRAPHIEN

Vorläufige Mitteilung

Verfasser beschreibt zuerst die Methoden welche bis jetzt bei der Untersuchung röntgenologisch-kephalometrischer Bilder allgemein verwendet worden sind (Tracing-Methode usw.) sowie die Fehlerquellen, die in diesen Methoden enthalten sind.

Hernach wird eine neue, die sog. Dreieckverschiebungs Methode erläutert welche auf folgenden Umständen basiert ist.

1) Zwecks genauer Messung der Bewegungen des Unterkiefers wird für die Dauer der Bildaufnahme an zwei Zähne des Unterkiefers der Versuchsperson (Inkisiv und Molar) mit Wachs eine kleine Bleikugel befestigt (Durchmesser 1,2 mm). Das Röntgenprofil der fehlerlos runden Kugeln verbleibt unverändert trotz kleiner Verschiebungen des Unterkiefers.

2) Die Verschiebung des Unterkiefers wird vermittels zweier auf einander volgender Belichtungen desselben Filmes abgebildet (Bilder 2 und 3).

Der genaue Mittelpunkt der auf dem Röntgenbilde sichtbaren runden Schatten der Bleikugeln wird mit einer scharfen Nadel durchstochen. Um die Genauigkeit zu erhöhen, arbeitet man unter Verwendung eines Vergrösserungsglases. Durch die Verschiebung dieser auf der Filmoberfläche sichtbaren kleinen Punkte, kann man eine entsprechende Verschiebung eines nach Belieben gewählten Punktes des Unterkiefers vermittels einer gewöhnlichen Dreieckverschiebung bestimmen. Zu diesem Zweck wird der hierfür konstruierte Dreispitzenzirkel verwendet, welcher "Tripod" genannt wird (Bild 4).

Nach Auffassung des Verfassers hat die oben dargelegte Methode folgende Vorteile:

1) Da die Photographierung auf denselben Film vorgenommen wird, werden die kumulativen Fehlermöglichkeiten der "Tracing"-Methode eliminiert. Die Messungsschärfe ist auch grösser als bei Verwendung zweier verschiedener Bilder.

2) Die wirkliche Verschiebung jedes beliebigen anderen Punktes kann festgestellt werden, und sog. Schattenverschiebungsfehler treten nicht auf.

3) Die Photographierung geht schnell vor sich, denn z.B. der Kassettenwechsel erübrigt sich. So ist die Möglichkeit der Veränderung der Kopfhaltung zwischen den Aufnahmen gering.

Ausser in Lateralprojektion können Photos auch in Frontal- und Basalprojektion aufgenommen werden, wobei die Lateralverschiebung des Unterkiefers und insbesondere des Gelenkkopfes untersucht und gemessen werden kann (die sog. Bennet-Bewegung).

Diese Methode wird bei den zurzeit stattfindenden Untersuchungen verwendet, welche den physiologischen Freibewegungsraum (free-way space), die Lage des Mittelpunkts der

Öffnungsbewegung des Unterkiefers bei verschiedenen Personen, sowie die Bewegungsbahnen der Gelenkköpfe bei Protrusions- und Lateralbewegungen betrifft.

REFERENCES

Björk, A., 1947: The Face in Profile. Svensk Tandl.-Tidskr. 40 suppl.

Higley, L. B., 1936: New and Scientific Method of Producing Temporo-Mandibular Radiograms. Internat. J. Orthodontia *22:* 983.

—»— & *Logan, R. A.*, 1941: Roentgenographic interpretation of certain condyle and menton movements. J. Am. Dent. Ass. *28:* 779.

Lundström, A., 1953: Cephalometric registrations as an aid in diagnosing malocclusions. Acta odont. scand. *XI:* 100.

Ricketts, R. B., 1950: Variations of the Temporomandibular joint as revealed by Cephalometric laminagraphy. Am. J. of Orth. *36:* 877.

Thompson, J. R., 1941: A cephalometric study of the movements of the mandible. J. Am. Dent. Ass. *28:* 750.

—»— 1946: The rest position of the mandible and its significance to dental science. J. Am. Dent. Ass. *33:* 151.

Thörne, H., 1953: The rest position of the mandible and the path of closure from rest to occlusion position. Acta odont. scand. *11:* 141.

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