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Cephalometric registrations as an aid in diagnosing malocclusions.

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An ever-increasing interest is being attached to cephalometric methods of investigation in scientific examinations and in orthodontic diagnostics, where the procedure provides a valuable step in the analysis of individual cases.

Its capabilities in the solution of many scientific problems in orthodontics are manifest. There seems to be, however, some uncertainty about how the individual analyses should be interpreted, especially as regards the choice of therapy.

This paper does not claim to offer a comprehensive solution of this problem, the points of view expressed being but personal reflections intended as a contribution to the general discussion of the subject.

The conception of a "normal" as advanced by SIMON (1922, 1925) seems to form a suitable basis for an examination of the problem. He determines the relation of the dentition to three mutually perpendicular planes, viz. the *ear-eye plane* (approximating to the Frankfort horizontal plane), the *median plane* (through the median line of the palate), and the *orbital plane* (through the mean of the two orbital points in the antero-posterior direction). SIMON has also discussed in detail the conception of a "norm", explaining how it might be defined with respect to the relation of the dentition to these planes. He maintains that it is impossible

to determine a norm for each individual. It is therefore necessary, or in any case expedient, to judge each case according to a standard common to all. This is obtained by calculating the arithmetic mean of a number of cases with "anatomically correct occlusions" which have been selected from the population.

The mean thus obtained is taken as a norm for the therapy. This SIMON justifies by stating that a "normal dentition" biometrically determined in this way must be regarded as "conforming to law". He holds that if it is possible to adapt the particular case to such a norm then a thoroughly satisfactory result from both aesthetic and functional aspects should be obtainable. The subjective factor invariably involved in treatment on an aesthetic basis is side-tracked and the difficulties associated with giving a practical definition of the normal dentition from a functional point of view are avoided.

This reasoning is open to criticism. In the first place it is questionable whether a norm obtained from selected cases with an anatomically correct occlusion may be satisfactorily employed. A selection such as that envisaged is always based on an empirical normal conception, involving a degree of subjectivity varying with the limits set: all workers cannot be expected to employ quite the same limits. Apart from this more theoretical objection it is by no means certain that treatment aiming for a mean for normal cases (mean norm) will result in any improvement in the individual case. The aim of all orthodontic treatment should be to convert inferior dentitions into satisfactory ones — *functionally* (*i. e.* in respect of chewing, speech and breathing), *prophylactically* (in respect of caries, parodontal and joint diseases) and *aesthetically*. It is doubtful whether these points will receive more specific attention if a mean norm is aimed at (cf. AXEL F. LUNDSTRÖM, 1923, and others).

SIMON'S conception is most intelligible when applied to post-normal and pre-normal occlusion, and it is particularly in such cases that cephalometric methods have been adopted as an aid to diagnosis and subsequent treatment. SIMON considers it practical to distinguish between the two types of post-normal cases in which either the upper or lower jaw displays antero-posterior deviation from the average relationship between orbital plane and dentition.

For example, in the case of post-normal occlusion with protraction of the upper jaw the primary object is to guide the upper

jaw back, whereas in the case of mandibular retraction it is the lower jaw that should be corrected.

SIMON maintains that these principles of treatment are of value both *aesthetically* and in the attempt to obtain *permanent results*. If it were possible to discover a simple metric system to replace the subjective judgment it would of course simplify matters considerably. It seems unreasonable, however, to expect that such a system could exist. The human profile is so complicated and varying that it is only possible to conceive an aesthetic opinion of it in the individual case, bearing in mind the size, shape and mutual relation of all the parts that compose it.

It may be found, for example, that a profile with a comparatively large nose will appear more harmonious if it is combined with a bi-maxillary protraction than if the two jaws have an average relationship to the orbital plane. Similarly, a protruding chin will have a striking effect on the profile — a fact that should be given due consideration when a change in the dentition is projected for aesthetic reasons. It would appear impossible therefore to prescribe a mean norm which would ensure an aesthetically satisfactory result (cf. A. M. SCHWARZ, 1937, and others). The aesthetic viewpoint is inherently subjective and should not be prejudiced by irrelevant metric construction.

A factor of special importance is the permanency of the result. Post-normal occlusion may again be taken as an example. Such cases can be treated either by retracting the maxilla (or by checking its forward growth) or by encouraging the forward growth of the mandible. Which of these alternatives is likely to yield the more stable results is so far unknown. It is difficult to suggest any reason why a retracted mandible should be more easily displaced forwards than a mandible normally situated. The same applies to a protracted maxilla. Surely it is quite reasonable to assume that a backward displacement would be equally difficult to achieve whether it were protracted, normally situated or retracted. These, however, are questions that must be cleared up before it is possible to decide whether a mean norm can be of value as a guide in treatment.

In the absence of any definite knowledge on this point it would seem more consistent to make an aesthetic estimation — however subjective it may be — the basis for reconstruction of antero-posterior malocclusions. If there is little to choose between a maxillary and a mandibular displacement from an aesthetic point

of view, it might prove advisable to centre the reconstruction on the jaw for which the antero-posterior displacement is most easily effected for the malocclusion in question.

The above reasoning may equally be applied to analyses of individual deviations from the mean norms obtained from profile radiographs (in accordance with methods and principles by BROADBENT, 1931, 1937, HOFRATH, 1931, DE COSTER, 1932, 1939, KORKHAUS, 1936, 1939; SCHWARZ, 1936, 1937; BRODIE, 1941; BJÖRK, 1947; MARGOLIS, 1947; DOWNS, 1948; RIEDEL, 1952, and others). Such photographs have definite advantages over extraoral registration, providing for example good visual impressions of the length of the apical bases, their mutual antero-posterior relation, and, more generally, an insight into the internal construction of the whole facial skeleton. A study of such pictures therefore ensures a sounder judgment of the possibilities of treatment, especially in cases of more complicated malocclusions. With the X-ray of the profile as a basis it may be easier to determine the type and the extent of the changes planned in the dentition than with just an ordinary clinical examination and, at the same time, it is easier to judge the limitations of the treatment. Where wider clinical experience is lacking profile radiographs will be found a great advantage. Such assessments of the differences between the existing and the projected profiles are not concerned with the mean norm but are purely individual assessments.

It might be in place here to discuss the value in diagnosis of the variation range of cases with "anatomically correct occlusions".

The simplest way of defining the limits for the normal variation is by means of the maximum and minimum values in a material. Such a procedure is, however, unsuitable, the boundary values being largely arbitrary and, moreover, dependent on the number of cases investigated (an increase in material giving a greater range).

The standard deviation has also been employed for determining the normal variation, and this method provides opportunities for a more definite characterization of the variability of material. As an example, practically the whole variation (99.7 %) is to be found within the limits $\pm 3 \times \text{the standard deviation}$, calculated from the mean value, and values outside these limits can be regarded as abnormal. Naturally this does not mean to say that such an extreme variant, simply because it is abnormal, is characterized by any imperfect state involving need of treatment. That would

be tantamount to maintaining for example that a man whose height is more than 196.2 cm is defective in his development. Generally speaking, one can talk of need of treatment only for individuals, who are inconvenienced in some way by their abnormality.

Great care is therefore indicated when establishing even extreme deviations from the average values in one or more respects. It may perhaps be said that it is particularly justified in such extreme cases to search for other possible disturbances (in the ordinary physical development or in circumstances necessitating definite treatment), but it is impossible to find any valid reason for treatment simply on the basis of a deviation in size or proportion from some standard.

KOSKI (1950), who has written an interesting review on cephalometric methods, is of the opinion that such arguments apply only to the variation of single uni-dimensional characteristics. If instead one uses several characteristics and "the ratios of these characteristics to each other exceed the limits of their own range of normality — expressed, for example, by $3 \times S. D.$, then we may speak of an abnormal individual or of an abnormal face".

It is evident that a face is better characterized by use of a number of, rather than from single, characteristics. Combining values for several ratios naturally makes it possible to localize pronounced deviations from average norms in a very satisfactory manner. Distinctive features do not in themselves justify treatment, however, as has already been pointed out.

A factor whose significance has been discussed in connection with the prognosis of the antero-posterior malocclusions is to be found in the inclination of the so-called Y axis (a line from the centre of the sella turcica to the gnathion) to the Frankfort horizontal plane (Downs 1948). Take for example a post-normal dentition in which this angle is comparatively large (so that the height of the face is great in relation to its depth at the gnathion); the prospect of correction would be less than if the angle were small (the depth of the face being large in relation to its height). This would explain a more pronounced forward development of the lower jaw in the latter cases than in the former in which the growth of the face is more vertical. The degree to which the inclination of the Y axis can be used as a measurement of the forward growth of the lower jaw is, however, uncertain. This angle is in fact determined partly by the height of the face, and there

is no reason to presume that a comparatively great height would be associated with a small forward growth of the lower jaw.

The variation in the forward development of the jaws would be best determined by successive X-ray observations of the individual profile. Such particulars may facilitate a better prognosis, though a detailed treatment of extensive material would be necessary in order to provide convincing evidence. The same applies to the inclination of the mandibular plane in relation to, for example, the Frankfort horizontal, to which angle TWEED (1946) and others attribute great significance in the prognosis for post-normal occlusion, since a large angle would imply a poor prognosis.

The registrations of the *freeway space* and the *path of closure* for the lower jaw from the physiological rest position to occlusion — introduced by THOMPSON (1941, 1946, 1949) — deserve special mention. In connection with pre-normal occlusion such registrations are of obvious value in differential diagnosis. By this means it ought to be possible to distinguish between "forced pre-normal occlusion" on the one hand, in which the mandible is forced forwards during closure by incorrect incisal guidance, and, on the other hand, the true prognathous lower jaw with abnormal forward development. In the treatment of pre-normal occlusion it is usually a simple matter to control clinically the path of closure by noting it when the mandible is relaxed and checking whether the patient can bite edge-to-edge, or nearly so, with the incisors. Such clinical determinations have been in use for a long time for these cases. In a case of "forced pre-normal occlusion" it may be necessary only to correct the inclination of the incisors in order to achieve normal occlusion.

In post-normal occlusion, however, a corresponding registration is appreciably more difficult to carry out clinically. There is therefore a demand for a method that will illustrate the degree to which these malocclusions are connected with forced occlusions, and which might provide a better prognosis than is at present possible in cases of malocclusion caused by abnormal relative antero-posterior growth of the jaws. It may prove that the best advance in this direction is gained by making profile X-ray studies of the lower jaw in a rest position and in occlusion, as pointed out by THOMPSON.

Accurate determinations of the error inherent in the method are essential, however, — particularly in registration of the rest

position — before it will be possible to decide the true value of this method.

The registration of the displacement of the mandibular condyle in closure from the rest position to occlusion is of particular importance when determining whether there is any post-normal "forced malocclusion". In the normal state no parallel displacement is assumed to take place; it is a hinge movement. In the post-normal "forced malocclusion", however, there is a displacement of the condyle backwards and upwards, in consequence of which condylar photographs must be regarded as essential complements to the profile radiographs in the examination (BLUME, BOMAN, 1947, as cited by THOMPSON, 1949, BOMAN, 1952).

The value in this connection of laminographs of the temporomandibular joint has recently been demonstrated by RICKETTS (1950, 1952). For a full appreciation of this method, however, the errors of observation (systematic and accidental) must be calculated.

THÖRNE (1951)¹ has presented a method for measuring deviations from the pure hinge movement in closing from rest position to occlusion. He found, in 31 cases of Angle's Class II, div. 1, 26 cases with a backward displacement of the mandible varying between 1 and 3.5 mm. In 9 cases of Angle's Class II, div. 2, only 1 had a pure hinge movement in closing and 8 cases showed a displacement backwards between 1 and 4 mm. In 26 cases with pre-normal occlusion there was only one where the mandible appeared to be displaced forwards ($\frac{1}{2}$ mm). 10 cases had the pure hinge movement, and 15 showed backwards displacement, some of them as much as 2.5 mm.

One possibility of an erroneous diagnosis which may perhaps be pointed out derives from the tendency that is shown by certain patients with post-normal occlusion to protrude the lower jaw in order to improve the profile. Such a fixed habit is a "forced malocclusion" in a backward direction, whereas in point of fact it is the registered "rest" position that is a "forced" position — forwards. This possibility is not contradicted by RICKETTS' (1952) discovery that the difference between cases with "normal" path of closure and cases with backward and upward thrusting of the condyle from rest to occlusion seems to depend upon different rest positions, does not contradict this possibility. Another ex-

¹ See also THÖRNE'S article in this number.

planation of his finding is of course, that the morphology of the jaw-joint is determined in relation to the position of the mandible in occlusion but not to the rest position.

Great value should be attached to all attempts that are being made to demonstrate the success gained in changing the profile in the upper and lower jaws by various methods (intermaxillary traction, treatment with plates, the use of occipital anchorage). This can be most simply carried out with the aid of cephalometric methods. Similar determinations have already been performed by some workers (*e. g.* BRODIE, DOWNS, GOLDSTEIN & MYER, 1938; EPSTEIN, 1946; HEDGES, 1946; COLE, 1947; LITOWITZ, 1947).

Differences between radiographs before and after treatment are, however, often difficult to interpret, and not least when they relate to long-term treatment of children. In these cases considerable development is going on simultaneously with the treatment, the growth varying appreciably from one case to another. These difficulties are pointed out in the above-mentioned work by BRODIE and co-workers with the result that they are very reserved in their conclusions. They call attention to the fact that extensive material must be investigated before it can be decided what changes in profile are obtainable through orthodontic treatment. In this respect it is of particular importance to investigate which changes might prove of a lasting character. At present there seems to be no reason for great optimism. Our capability for reconstructing the facial skeleton appears somewhat restricted.

Summary.

The clinical importance of cephalometric determinations is a question that cannot be considered sufficiently investigated. In this article the problem has been discussed from various angles. The following points have been treated:

1. The questionable value of comparing individual cases with such standards as means and variation ranges derived from cases of so-called "anatomically correct occlusions".
2. The value of determinations of differences between the existing and the proposed profiles.
3. The forward growth of the mandible and the inclination of the mandibular plane in relation to prognosis in treating antero-posterior malocclusion.

4. The profile radiographs in the rest position and occlusion and the X-rays of the temporomandibular joints as a means of differentiating between "forced malocclusion" and more inherent anteroposterior anomalies.

5. Profile radiographs as a means for assessing the changes effected by orthodontic treatment.

Zusammenfassung.

Die klinische Bedeutung von cephalometrischen Bestimmungen ist ein Problem, das nicht als genügend untersucht betrachtet werden kann. In diesem Artikel ist das Problem aus verschiedenen Gesichtspunkten betrachtet worden. Folgende Punkte wurden behandelt:

1. Der fragliche Wert, einzelne Fälle mit Mittelwerten und Variationsbreiten, die von Fällen von sogenannter "anatomisch richtiger" Ocklusion abgeleitet worden sind, miteinander zu vergleichen.

2. Der Wert, die Differenzen zwischen den vorhandenen und den beabsichtigten Profilen festzustellen.

3. Die Vorwärtsentwicklung der Mandibel und die Inklination der mandibulären Ebene im Verhältnis zu der Prognose bei der Behandlung von antero-posteriore Malockklusionen.

4. Die Röntgenprofile in der Ruhelage des Unterkiefers und bei der Ocklusion und die Röntgenbilder des Kiefergelenkes als ein Mittel um Zwangsbiss und mehr angeborene antero-posteriore Malockklusionen von einander zu unterscheiden.

5. Profiliröntgen als eine Methode, die durch orthodontische Behandlungen entstandene Veränderungen festzustellen.

Résumé.

L'importance chimique des déterminations céphalométriques est une question qui ne peut être considérée comme suffisamment examinée. Dans le présent article, le problème a été discuté de divers points de vue. Les points suivants ont été considérés:

1. La valeur douteuse de la comparaison de cas individuels avec des modules telles que moyens et échelles de variation, dérivées des cas "d'occlusions anatomiquement correctes".

2. La valeur des déterminations de différences entre les profils existants et ceux proposés.

3. L'accroissement en avant de la mandibule et l'inclination du plan mandibulaire en relation au pronostic en traitant la malocclusion antéro-postérieure.

4. Les profils radiographiques dans la position de repos et l'occlusion et des rayons X des joints temporo-mandibulaires comme un moyen de différencier la "malocclusion forcée" des anomalies antéro-postérieures plus inhérentes.

5. Profils radiographiques comme une méthode d'évaluer les changes occasionnés du traitement orthodontique.

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