The PCSO Bulletin is proud to introduce a new column, edited by UCSF Clinical Professor, Ib Leth Nielsen, DDS. His initial article reminds us of some of the values of headfilm analysis and some of the pitfalls. For future columns, he will invite articles from others who are faculty in the PCSO orthodontic programs, both in the U.S. and Canada.

FACULTY Files

WHAT YOU MAY HAVE FORGOTTEN ABOUT CEPHALOMETRIC ANALYSIS

BY IB LETH NIELSEN, DDS

When Hofrath in Germany and Broadbent in the USA introduced the radiographic headfilm technique to orthodontists in 1931, it initiated a new era in orthodontic diagnosis and treatment planning. Around the turn of the 20th century, Angle and his followers could only plan treatment based on the patient's facial profile and the malocclusion of the teeth. With the introduction of radiographic headfilm technique, orthodontists could plan their treatment using radiographic information about the patient's facial skeleton. Many possibilities opened up for orthodontists that to this day have proven an invaluable help in treatment planning, analysis of growth and treatment and prediction of possible treatment outcomes. In the following we shall discuss the technique and application of cephalometric analysis in several areas where this technique is used today:

a) Cephalometric morphological analysis of individual headfilms
b) Growth and treatment analysis
c) Growth and treatment prediction or simulation

In this first *Faculty Files* article, we will focus on the morphological analysis. In later articles we will describe the growth and treatment analysis and the prediction or simulation of growth and treatment.

MORPHOLOGICAL ANALYSIS

The main area of application of cephalometrics today is in the description of a patient's facial profile, in a so-called *morphological analysis*. A main purpose of a cephalometric analysis is to determine departures from the average in skeletal and dento-alveolar morphology. The information gathered from such a single headfilm is limited and represents information about the face in profile at one time point and says very little about future growth and development of the face. With the information gathered from many of the numerous analyses available today, it is possible, however, to determine whether the malocclusion is related to skeletal or dento-alveolar deviations, which is very valuable to the orthodontist in the treatment planning phase. Some analyses also enable the clinician to determine if there is dento-alveolar compensation or dysplastic development in a patient with a skeletal discrepancy and where this change is located.

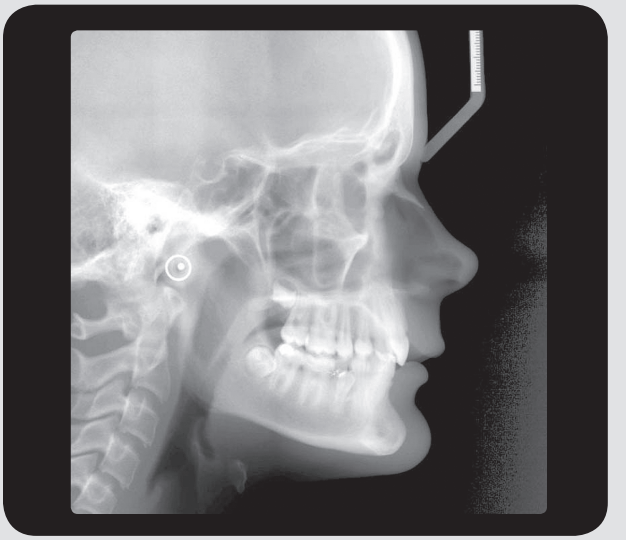

Figure 1

This type of analysis basically describes the facial make-up of an individual, so to speak, and is somewhat limited in its clinical values. It should therefore be reduced to parameters that are meaningful and informative.

Today there are many morphological analyses available to the clinician. Most are based on individual preferences and frequently lack sufficient data base to support the use on larger groups of individuals. In this area of facial analysis more numbers are not necessarily better, and often serve only to confuse the clinician. As a result, the analysis becomes an exercise in futility and does not provide much help with treatment decisions.

Most orthodontists are aware that averages or mean values should not be applied to the individual case. The mean values are only a guide to help determine an individual's facial make-up and the standard deviations indicate the extent of the variation from the mean. Nevertheless, these mean values are sometimes used as treatment goals with the interpretation that if the individual does not fit the mean, something is wrong. This concept of means, or "norms," is misleading and erroneous as it can make the orthodontist think he or she should treat patients to a given mean value. The fact of the matter is that all the mean values we routinely use are associated with large standard deviations, which demonstrate the great variability within the normal population. We also should remember that in the U.S. there are many different ethnic groups. The esthetic goals from one population may be very different for another.

A misunderstanding that we frequently encounter is the incorrect use of the concept of the standard deviation. The fact that a measurement of a skeletal discrepancy is within one standard deviation does not mean that it is almost normal and therefore insignificant. There are in most cases several components involved such as the protrusion of the maxilla, the prognathism of the mandible and the shape of the cranial base. Each of these parameters can be within one standard deviation, but if they go in opposite direction, amount to a pronounced discrepancy.

In a cephalometric analysis, it is preferable to use angular rather than linear measurements, as angular measurements vary little due to size and age differences between individuals. The use of linear parameters should always be accompanied by a respect for the wide individual variability.

The cephalometric values in general must be used with caution and only as guides to what area or structure an occlusal problem may be related and the numbers serve only as guides — not as a target. Most cephalometric analysis are so-called "component analysis" that provide information as to relationships between facial and dental components in the horizontal, vertical and transverse dimension.

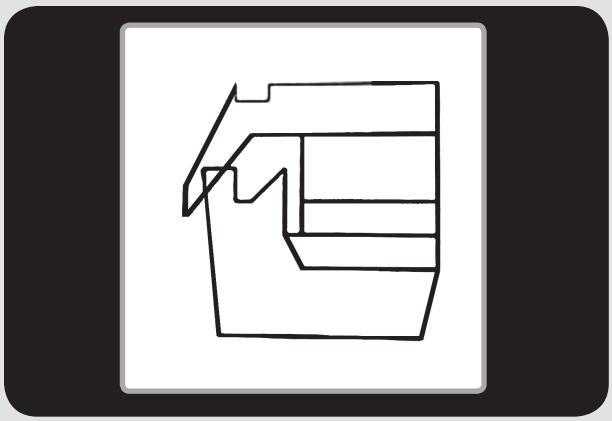

Figure 2 (From Solow, 1980)

As seen in Fig. 2, the facial components consist of the cranial base, the maxilla and the mandible. In addition, there is an upper and a lower dento-alveolar component.

The facial components are highly correlated to each other and changes in their sagittal and vertical position influence the dento-alveolar relationships and thereby the occlusion of the teeth. One example is the cranial base which depending on its shape, can affect the position of the jaws. If, for instance, the median cranial base, as measured by the (N-S-Ba) angle, is increased or more obtuse than normal, it frequently is associated with bimaxillary retrognathism. Conversely, an acute cranial base angle is associated with bimaxillary prognathism.

SKELETAL AND DENTO-ALVEOLAR MALOCCLUSIONS

The association between malocclusion and the dento-alveolar and skeletal components present can be illustrated in case of excessive overjet, as seen in Figure 3. The possible combinations of dental, alveolar and skeletal deviations that can cause an excessive overjet are illustrated as seen below.

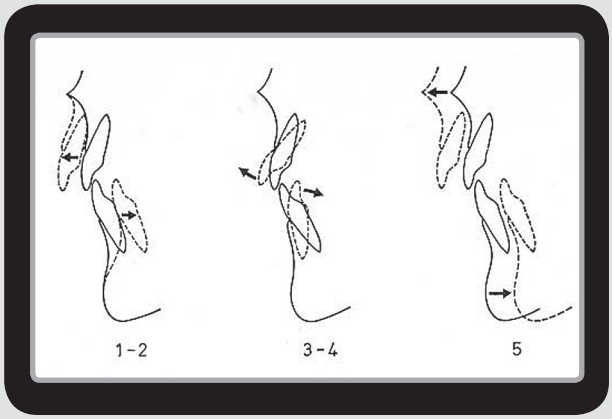

Figure 3 (From Björk, 1974)

Illustration (1-2) shows the alveolar changes that can result in an overjet; maxillary alveolar protrusion, mandibular alveolar retrusion or a combination of the two; (3-4) shows the possible variations in maxillary or mandibular incisor inclination; and (5) the skeletal relationships where maxillary protrusion, mandibular retrognathism or a combination thereof can result in an excessive overjet. In other words, variations in overjet can be expressed through five factors that each can be increased, reduced or remain unchanged during the development. This yields a total of 3^5=243 possible combinations for variations in the development of the overjet. It should remind us of the importance of developing a differential diagnosis for each patient in order to correctly address the problems at hand.

DENTO-ALVEOLAR COMPENSATION

Another biological phenomenon that is critical to a successful treatment outcome is to recognize and understand the role of dento-alveolar compensation. In patients with sagittal, vertical or transverse skeletal discrepancies, there is often a considerable amount of dento-alveolar compensation. This biological mechanism often masks the actual skeletal deviations and must be considered during treatment planning. In most patients, it is necessary to reduce or remove the compensation in order to achieve a skeletal

correction, especially in growing patients and adults who are planned for orthognathic surgical correction. In other patients, it may be desirable to maintain the compensatory changes or even accentuate them to achieve an acceptable treatment result.

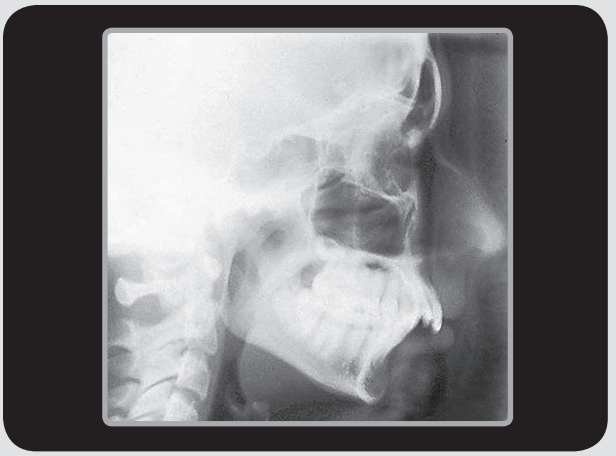

Figure 4

In the example seen in Figure 4, the patient has a Class II, Div. 1 malocclusion due to a retrognathic mandible. The lower incisors show compensatory proclination as the natural biological attempt to mask the skeletal problem (*Solow*, 1980). No compensation is seen in the maxilla where the teeth are dysplastically proclined, possibly due to a lip habit. In this patient, surgical correction through mandibular advancement was planned so the orthodontic treatment was directed towards reducing the compensation to maximize the mandibular advancement. The concept of dento-alveolar compensation has been incorporated not only in the Björk (1961) analysis, but in other analysis as well on a more or less intuitive basis. For example, Steiner (1959) developed a series of acceptable compromises for variations in the sagittal jaw relationship. As seen in Fig. 5, varying jaw relationships, according to Steiner, require different changes in upper and lower incisor inclination for an acceptable occlusion of the anterior teeth.

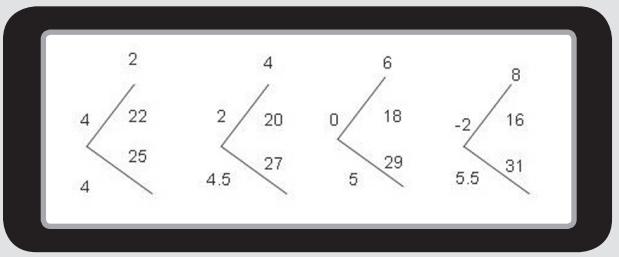

Figure 5 (From Steiner, 1959)

A further step towards incorporating compensation in treatment planning has been put forward by Ricketts (1957), who set up treatment goals in his visual treatment plan incorporating compensation for variations in the jaw relationship. He used a line from point A to Pog as a so-called "compensation line," and related the incisal edge of the lower incisor to this line. By relating the incisal edge to this line, he automatically introduced a certain amount of dental compensation. Then different positions would be developed relative to the individual facial growth type.

The approach to analyzing a headfilm should, first of all, concentrate on determining the jaw relationship and then on to what extent departures from the normal jaw relationship have been compensated in the dento-alveolar structures. The goal for treatment will then depend on whether the skeletal problem is best corrected by growth modification, tooth movements or surgical correction.

PREDICTIVE POWER OF THE LATERAL HEADFILM

As to the predictive value of individual headfilms, it is possible to some degree to predict the quality of future facial growth and in particular of mandibular growth. *Björk* (1966), in his facial growth studies of the mandible, demonstrated that certain stable structures in the mandible could consistently be relied upon as indicators of future growth rotation of this jaw. He also emphasized that these structural signs were only indicators and had the greatest predictive value in the more pronounced cases of mandibular growth rotations.

After many years of continued research into area of mandibular growth, *Björk and Skieller* (1972) concluded that by using additional signs such as inter-molar angle, shape of the lower border of the mandible, and inclination of the mandibular symphysis, it was possible to improve the predictability of growth rotation of the mandible. In this context it should be emphasized that the majority of untreated patients demonstrate some degree of anterior or forward growth rotation of the mandible. Orthodontic treatment, however, influences the rotation of the mandible depending upon maxillary growth changes and the extent of upper and lower molar eruption during treatment.

Posterior or backward rotation is seen only in a small percentage of patients and is in the more pronounced cases predictable with a great degree of certainty. The importance of forward growth rotation of the mandible is that it is associated with a favorable anterior displacement of the chin and the potential for improvement in a deficient jaw relationship. Posterior or backward mandibular growth rotation, on the other hand, is associated with no forward

mandibular displacement and in some instances may make the facial balance worse. There are several other positive implications of this rotational change that relate to the actual treatment, the treatment mechanics and the post treatment stability, which is outside the scope of this description of the application of cephalometric analysis.

WHAT DOES IT ALL MEAN?

The initial analysis of the lateral headfilm is an important part of the work up of the patient. The information gathered should be an integral part of the diagnosis and guide the clinician towards the right treatment plan. Differentiating between skeletal or primarily dento-alveolar malocclusions is important, as it tells the clinician what problems he or she is dealing with. It is just as important in this case to determine if dysplastic changes have taken place, as it is in cases with skeletal problems to discern if dento-alveolar compensations are present. Then it must be decided to what extent this compensation needs to be removed in order to achieve an ideal result. In cases where there are the so-called dysplastic changes, it is frequently an indication that some form of soft tissue problem such as a lip habit, tongue thrust or airway problem is present that needs to be taken into consideration. A careful cephalometric analysis is therefore not only a great help in locating the problems, but often points to what needs to be corrected and should not be ignored as an integral part of the treatment planning. It is important to remember that meaningful data can be obtained from the headfilm and if the information is carefully applied, it can guide the clinician towards the correct treatment plan for the patient.

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